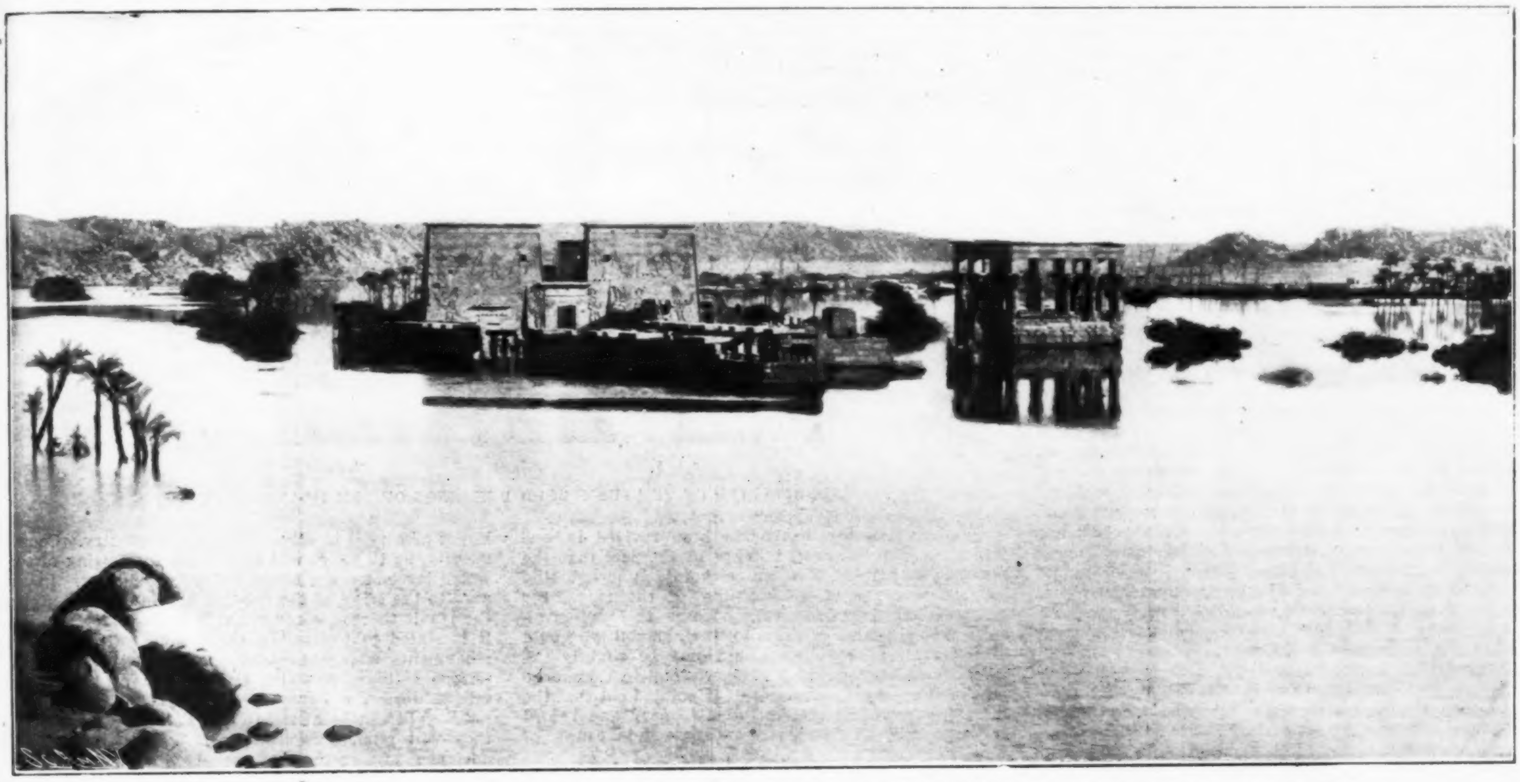
SCIENTIFIC AMERICAN SUPPLEMENT. No 1639

Entered at the Post Office of New York, N. Y., as Second Class Matter. Copyright, 1907 by Munn & Co.

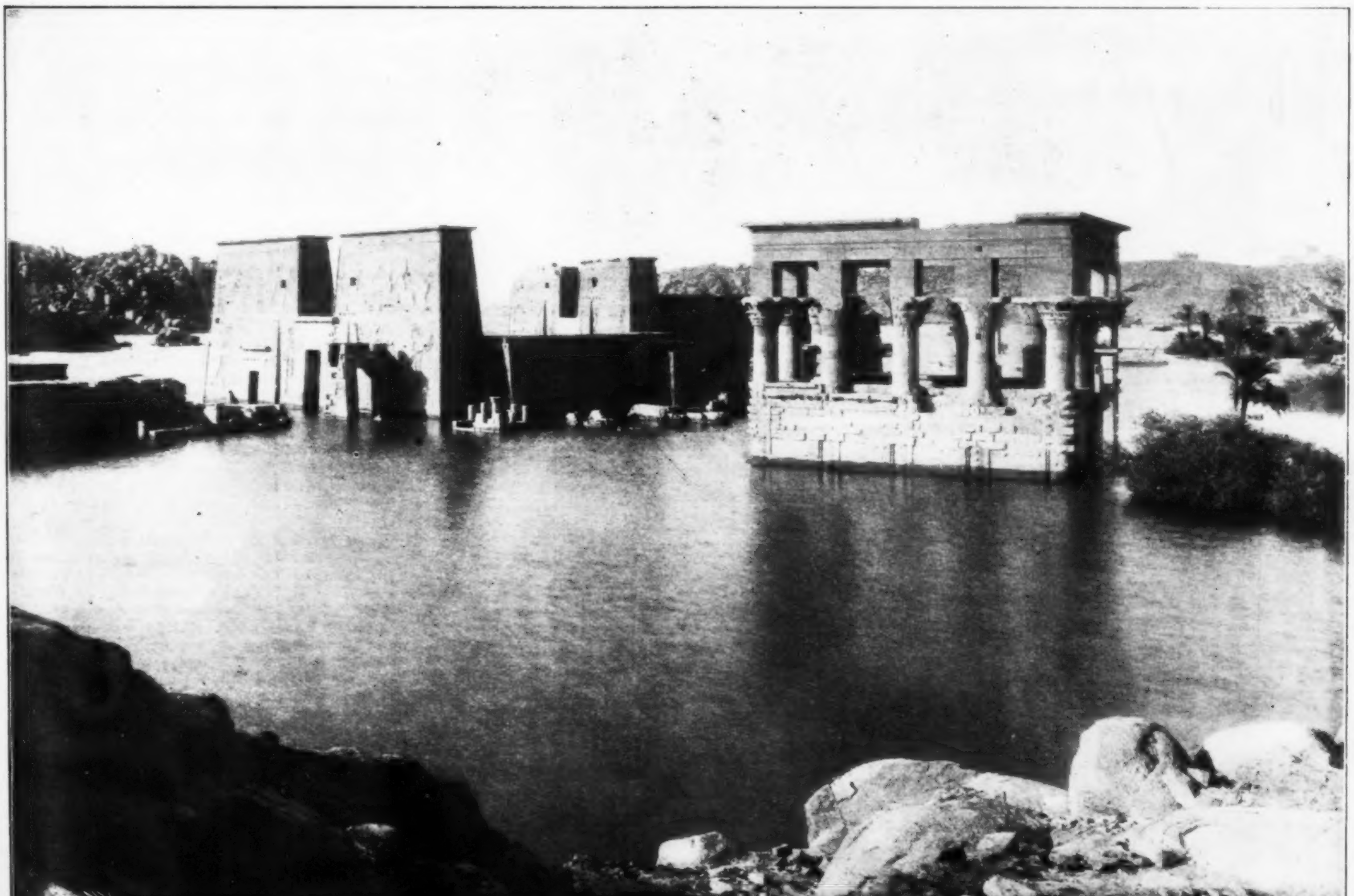
Scientific American, established 1845.
Scientific American Supplement, Vol. LXIII., No. 1639.

NEW YORK, JUNE 1, 1907.

Scientific American Supplement, $5 a year.
Scientific American and Supplement, $7 a year.



GENERAL VIEW OF THE RUINS OF PHILÆ, SHOWING THE ISLAND COMPLETELY SUBMERGED, THE TEMPLES ONLY BEING VISIBLE.



SUBMERGENCE OF THE ISLAND OF PHILÆ CAUSED BY THE DAM AT ASSOUAN.

THE FATE OF THE TEMPLES OF PHILÆ.

THE FATE OF THE TEMPLES OF PHILÆ.

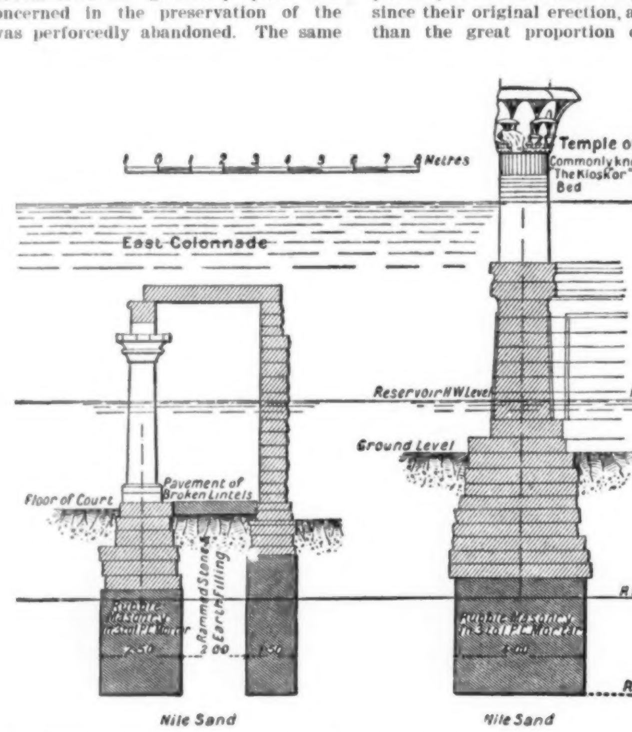
By the English Correspondent of Scientific American.

Apprehension is being entertained in archeological circles concerning the ultimate fate of the ruins of the Temple of Philæ as a result of the projected increase in height of the Assouan barrage across the Nile by 23 feet. The addition in the area and depth of water impounded in consequence of this development will cause the almost complete submersion, during a portion of the year, of these and other interesting monumental links with ancient Egypt existing in the Nubian Valley. While sympathizing with the efforts to preserve these archeological relics, Sir William Garstin, G.C.M.G., who is the adviser to the Egyptian Ministry of Public Works, emphatically points out that sentimental interest must to a certain degree be stifled if the prosperity of the country is to be increased. Every possible alternative scheme for storing additional water has been carefully considered, but unfortunately has had to be abandoned for reasons of impracticability. The only two methods available is the impounding of the required quantities of water in reservoirs constructed in the Nile Valley, and also the prevention of wastage of water in the vast Bahr-el-Gebel marshes, which is at present considerable, so that the volume of water carried by the river beyond Khartoum during the summer months may be appreciably increased. Sir William Garstin points out that both these schemes must be brought to fruition, but that the former is the more pressing at present, and can be carried to completion in a much shorter period to the advantage of the perennial irrigation of the country. Consequently, this project is to be undertaken first, but no further increase in the height of the dam will be considered after the present extensions are fulfilled, for the simple reason that a sufficient supply of water will not be left in the river for navigation purposes.

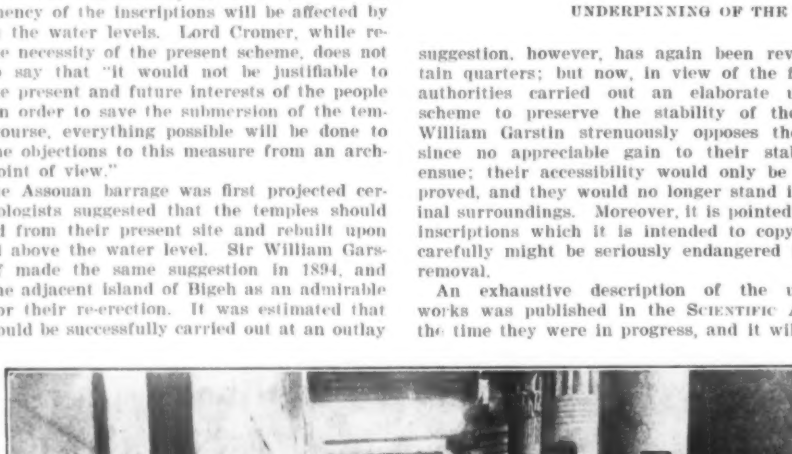
Great stress has been brought to bear upon the authorities to avoid the subsequent flooding of the Philæ temples which must inevitably ensue, fears being expressed as to how the stability of the structures and the permanency of the inscriptions will be affected by the rise in the water levels. Lord Cromer, while regretting the necessity of the present scheme, does not hesitate to say that "it would not be justifiable to sacrifice the present and future interests of the people of Egypt in order to save the submersion of the temples. Of course, everything possible will be done to mitigate the objections to this measure from an archeological point of view."

When the Assouan barrage was first projected certain archeologists suggested that the temples should be removed from their present site and rebuilt upon a spot well above the water level. Sir William Garstin himself made the same suggestion in 1894, and proposed the adjacent island of Bigeh as an admirable situation for their re-erection. It was estimated that the work could be successfully carried out at an outlay of approximately $1,000,000. This idea was stimulated by the fact that the foundations of the temples were not of a sufficiently stable character to resist any erosion that might result from the increased water level. But this proposal raised such a storm of dissent and disapproval from the greater proportion of archeologists concerned in the preservation of the relics, that it was perforcedly abandoned. The same suggestion, however, has again been revived in certain quarters; but now, in view of the fact that the authorities carried out an elaborate underpinning scheme to preserve the stability of the ruins, Sir William Garstin strenuously opposes their removal, since no appreciable gain to their stability would ensue; their accessibility would only be slightly improved, and they would no longer stand in their original surroundings. Moreover, it is pointed out that the inscriptions which it is intended to copy and record carefully might be seriously endangered in course of removal.

An exhaustive description of the underpinning works was published in the Scientific American at the time they were in progress, and it will be remembered that the original friable foundations were completely removed and masonry carried right down to the solid rock of the river-bed laid in its place. Consequently, the complete stability of the structures is now assured, and it is pointed out that the ruins are probably safer now than they have been at any time since their original erection, and are certainly far safer than the great proportion of the relics of ancient Egypt preserved in other parts of the country. Consequently, no ill effect will arise from the raising of the water levels from a structural point of view. In regard to the effect of the flooding upon the inscriptions, the result thereof is somewhat difficult to foretell, but it is stated that those on the higher portions of the monuments which have not been subject to the deleterious salts with which the rubbish of the Coptic village formerly covering their bases was impregnated, will not be affected; and it is anticipated that they will remain as clearly cut and distinct as the ancient marks on the quay walls, and which have been submerged beneath the level of the river for centuries. The increased level of the water will render the temples somewhat more inaccessible from the winter visitor's point of view, but it is pointed out that they will be possible of inspection during the months between July and October, during which period they will be annually uncovered.



UNDERPINNING OF THE SUBMERGED BUILDINGS OF THE ISLAND OF PHILÆ.



COLONNADE LOOKING SOUTH. READY FOR THE LAST LENGTH OF MASONRY. THE TRENCH IS PARTLY FILLED IN AT THE FARTHER END.

THE FATE OF THE TEMPLES OF PHILÆ.

WOMEN AT WORK IN THE UNITED STATES.

The Census Bureau has just issued a report presenting statistics of women at work. It is a publication of nearly 400 pages prepared under the supervision of Dr. Joseph A. Hill, and based upon unpublished information derived from the schedules of the Twelfth Census. Women at work are here classified not only by age, race, nativity, marital status, and occupation, but also by their relationship to the families in which they live and the number of other bread winners, or persons at work, in those families. The latter classifications are a new feature in the treatment of the occupation data compiled by the census. For the most part, the family unit has heretofore been ignored in the census statistics of occupations, and the breadwinner or worker has been treated as an independent individual. Yet from an economic standpoint the family group is a unit of great significance. The earnings of the bread winner, whether man, woman, or child, usually form either the whole or a part of a family income, which limits the family expenditures and affects the economic welfare of each member of the family.

The term "woman" as used in this report generally includes all females 16 years of age and over; but in some instances, in order to make comparisons with the census of 1890, the age limit is lowered to 15 years.

In the United States the number of women at work as returned by the census of 1900 was almost five million. In continental United States—by which is meant the United States exclusive of Alaska, Hawaii, and all other outlying territories or possessions—the exact number was 4,833,630.

RACE AND NATIVITY.

The total number includes 1,771,966 native white women whose parents also were natives; 1,090,744 native white women one or both of whose parents were immigrants; 840,011 white women who were themselves immigrants; 1,119,621 negro women; and 11,288 Indian and Mongolian women. Thus the native white women of native parentage constituted 36.7 per cent, or more than one-third, of the total number of women who were bread winners, the other classes being represented by the following percentages: Native white of foreign parentage, 22.6; foreign born white, 17.4; negro, 23.2; Indian and Mongolian, two-tenths of 1 per cent.

AGE.

Most of the women at work were young women; 68.4 per cent of them were under 35 years of age, 44.2 per cent were under 25, and 25.6 per cent had not reached the age of 21. These figures are in marked contrast with those for the male sex. Of the men 16 years of age and over reported as workers or bread-winners, only 24.7 per cent were under the age of 25 and only 12.7 per cent were under 21. This contrast is indicative of the fact that large numbers of women who support themselves and others in early life cease to be bread winners upon assuming the responsibilities of marriage and child-bearing.

MARITAL CONDITION.

This conclusion is substantiated by the statistics of marital or conjugal condition. Almost two-thirds, or 65 per cent, of the total number of women at work were single, while 15.9 per cent were married, 17.7 per cent were widows, and 1.3 per cent were divorced.

PROPORTION OF WOMEN AT WORK.

The total number of women 16 years of age and over in continental United States in 1900 was 23,485,559. The number at work constituted 20.6 per cent of this total. In other words, 1 woman in every 5 was a bread winner, that term being used to designate persons reported by the census as following a gainful occupation. Of the total male population of the same age—that is, 16 years and over—90.5 per cent were bread winners. This difference between the sexes as regards the percentage of breadwinners is probably not greater than would be anticipated. Men take up some occupation almost as a matter of course, and usually follow it the greater part of their lives. With women the adoption of an occupation, although by no means unusual, is far from being customary, and in the well-to-do classes of society is exceptional. Moreover, the pursuit of an occupation by women is probably more often temporary than permanent.

The percentage of bread winners among women varies widely in different classes and at different age periods. The influence of age differences is shown by the fact that while the percentage of bread winners is 32.3 for women 16 to 20 years of age and 30.8 for those 21 to 24 years of age, it is only 19.9 for those 25 to 34 years, and becomes still smaller in the older age groups. In other words, more than 30 per cent of the women under 25 were at work, but hardly 20 per cent of those between 25 and 35, and considerably less than 20 per cent of those over 35.

This difference is directly attributable to marital condition rather than to age. The principal reason why the older women comprise a smaller percentage of bread winners is not that they are older, but that more of them are married. The contrast between the marital classes is very marked. Of the single women, 45.9 per cent were at work; of the married, only 5.6 per cent. For widows the percentage is 31.5—not as high as that for single women, but much higher than that for the married.

DIVORCED WOMEN AT WORK.

The number of divorced women returned by the census is probably deficient because the fact of divorce is not always admitted. But it is significant that of the number reported as divorced at the time of the twelfth census, 55.3 per cent, or more than one-half, were supporting themselves wholly or in part by their own earnings. This is a higher percentage of bread winners than was shown for women in any other marital class. It has been suggested that the increase of divorce is partly attributable to the more independent economic position of women, as a result of which wives are better able to provide for themselves and less dependent upon their husbands. The figures compiled by the census appear to be consistent with this theory, although they can not be said to prove it.

THE NEGRO AND THE IMMIGRANT.

Of the negro women, 43.2 per cent were bread winners; of the white, 17.8 per cent. For the native white born of native parentage the percentage is only 14.6, representing about 1 woman in 7; while for the native white of foreign parentage the percentage is 25.4, which is equivalent to 1 woman in every 4. Of the foreign born white women, 19.1 per cent were bread winners, or approximately 1 woman in 5. It may seem strange that the percentage should be smaller for them than for the native white women whose parents were foreign born; for it would probably be assumed that immigrant women, as a class, would be under a greater necessity of supporting themselves or of contributing to the support of their families than the native women whose parents were immigrants. A further analysis of the statistics tends to confirm this assumption, since it appears that the difference between the two classes as regards the percentage of bread winners is mainly a result of the difference in age. The native white women whose parents were immigrants are as a class considerably younger than the white women who were themselves immigrants. Of the former, 35.4 per cent were under 25 years of age; of the latter, only 16.2 per cent. If the comparison between the two classes is restricted to young women, the percentage of workers is found to be considerably higher among the foreign born than among natives whose parents were foreign born.

INCREASED EMPLOYMENT OF WOMEN.

The extent to which women are engaged in bread winning pursuits is increasing. At the census of 1880 the number of women 16 years of age and over reported as having a gainful occupation was 2,353,988; in 1900 it was 4,833,630, an increase of 2,479,642, or 105.3 per cent. In other words, the number of women at work more than doubled in this interval of twenty years. Of course the increase was in part the result of the growth of population. But this accounts for not much more than one-half of the total increase, and it is probable that there were over a million women engaged in gainful occupations in 1900 who would not have taken up such occupations if conditions and tendencies had remained the same as they were twenty years before. The increasing participation of women in industrial pursuits is indicated by the increase shown in the percentages. Of the women 16 years of age and over, 16 per cent were at work in 1880, 19 per cent in 1890, and 20.6 per cent in 1900.

A comparison with the census of 1890 as regards the number of women who are bread winners in each marital class reveals a very noticeable increase in the employment of married women. As already pointed out, the percentage of bread winners among married women is small as compared with the corresponding percentages for single, widowed, and divorced women; but it increased from 4.6 in 1890 to 5.6 in 1900, which means that aproximately 1 married woman in 18 was at work in 1900, as compared with 1 in 22 in 1890 or that the proportion at work increased by almost one-fourth.

FAMILY RELATIONSHIP.

For the purposes of this report the women at work in the principal cities of the United States were classified with respect to their relationship to the heads of the families in which they lived. The total number of women included in this classification was 1,232,268; and of this number 798,711, or 64.8 per cent, were living at home or with relatives, while 433,557, or 35.2 per cent, were either boarding or living with their employers. The importance of the latter class is greatly increased by the large number of servants living with their employers. Excluding servants, whose position in this classification is largely determined by the nature of their occupation, and also waitresses, who in the census classification are not distinguishable from servants, the total number of bread winners included in this tabulation is reduced to 904,695; and of this total 731,665, or 80.9 per cent, were living at home and 173,030, or 19.1 per cent, were boarding. The number boarding includes, as before, those living with their employers, but comparatively few women other than servants come in this class.

The tabulation further indicates that 14.4 per cent of the women at work (not including servants and waitresses) were heads of families, while 33.7 per cent were living with fathers, 15.5 per cent with mothers, and 17.2 per cent with other relatives. The percentage of boarders does not vary widely in the different marital classes. Of the single women at work, other than servants and waitresses, 19.8 per cent were boarders; of the married, 15.1 per cent; and of the widowed and divorced, 18.4 per cent. The majority of the widowed and divorced—64.4 per cent of the total number included in this tabulation—were returned as heads of families. Naturally, comparatively few single women were so returned—only 4.7 per cent—while 43.5 per cent were returned as living with fathers.

It is rather significant that 15,712, or 16.1 per cent, of the 97,477 married women included in this tabulation were returned as heads of families, because this indicates that at least that number were living apart from their husbands. In the census enumeration no woman living with her husband would be designated as the head of the family, however strong her claim to that distinction might be. It is probable, moreover, that many of the 23,830 married women returned as living with fathers or mothers or as boarding were likewise separated from their husbands. On the whole, then, a study of these figures points to the conclusion that to a considerable extent the employment of married women represents wife desertion, through which the wife is compelled to rely upon her own exertions for a living.

OTHER BREADWINNERS IN THE FAMILY.

Some idea of the extent to which the wages earned by women are supplementary to the earnings of other members of the family, and represent, therefore, only a part of the total family income, is obtained by a classification of the women who are bread winners with respect to the number of other bread winners in the family. This classification, like that by family relationship, is presented for the principal cities of the United States. Not counting servants and waitresses, the total number of female bread winners included in this classification was, as stated above, 904,695. Of this total, 632,804, or almost 70 per cent, were living at home in families in which there were other bread winners; of these, 226,300, or 25 per cent, were living in families in which there were at least three other bread winners, making a total of at least four bread winners in the family. These represent the cases in which the earnings of the woman who was a bread winner were presumably supplementary to those of other members of the family. Under such circumstances her earnings might not be sufficient for her own support, but would nevertheless contribute something to the total family income, either lessening the burden resting upon other bread winners in the family or providing herself with personal comforts or luxuries which she might otherwise have to forego. The effect which the situation revealed by these statistics may have upon the wages which women receive is, of course, an interesting question, but is one which is not discussed in the present report.

It is to be presumed that most of the working women who were returned as boarding were at least supporting themselves, and some of them, of course, may have contributed to the support of relatives living elsewhere. The boarders, as previously stated, constituted 19.1 per cent, or about one-fifth, of the total number of working women, exclusive of servants and waitresses.

The women who were living at home in families having no other bread winners constituted only about one-tenth of the total number included in this tabulation. Their position would suggest that they were supporting not only themselves, but other persons dependent upon them. But that does not necessarily follow, since some of them may have had no relatives or dependent persons living with them and some may have been assisted by relatives living elsewhere.

On the whole, therefore, this analysis indicates that only a small minority of the working women are entirely dependent upon their own earnings for their support and that a still smaller number are supporting families unassisted.

OCCUPATIONS OF WOMEN.

In the reports of the twelfth census (1900) the detailed classification of bread winners with respect to the kind of work in which they were engaged distinguishes 303 occupations. Women are represented in all but nine of these occupations. Naturally no women were reported as United States soldiers, sailors, or marines; nor were any reported as members of the fire department, or as street car drivers (though two were reported as motormen), or as telegraph and telephone linemen, or as apprentices or helpers to roofers and slaters, or as helpers to steam boiler makers or to brass workers. But the reader may note with interest, and perhaps with some surprise, that five females were employed as pilots; that on steam railroads ten were employed as baggagemen, thirty-one as brakemen, seven as conductors, forty-five as engineers and firemen, and twenty-six as switchmen, yardmen, and flagmen; that forty-three were carriage and hack drivers; that six were reported as ship carpenters, and two as roofers and slaters; that as many as 185 were returned as blacksmiths and 508 as machinists; that eight were boilermakers; that thirty-one were charcoal, coke, and lime burners; and that eleven were well borers. Of course these figures have little economic or sociological significance beyond indicating that there are few kinds of work from which the female sex is absolutely debarred, either by nature or by law or custom. There were 125 occupations employing over 1,000 women each and sixty-three employing over 5,000.

Notwithstanding the increasing diversity of employments for women, domestic service still remains the most important by far of the occupations in which they are engaged. Of the 4,883,630 women in continental United States reported as engaged in gainful occupations at the time of the twelfth census, 1,124,383, or almost one-fourth of the total number, were returned as servants. It may seem surprising that the next most important occupation for women is that of farm laborer, and that the number of women reported as following this occupation was 456,405, or almost half a million. The significance of the figures will be better understood if it is pointed out that 442,006, or 96.8 per cent, of these female farm laborers were reported from the Southern States, and that 361,804, or 79.3 per cent, of the total number were of the negro race. Moreover, it appears that 277,727, or 60.9 per cent, of the total number were members of the farmers' families, representing the wives and grown-up daughters assisting in the work on the home farms. Next to these two leading occupations come four occupations not far apart in numerical importance, though widely different in character. They are the occupations of dressmaker, laundress, teacher, and farmer. The largest of these occupations—that of dressmaker—employed 338,144 women, and the smallest—that of farmer—employed 307,206; of teachers, there were 327,206; of laundresses, 328,935.

Three-fifths of the total number of women reported as breadwinners were found in the 6 occupations employing more than 300,000 women each, the aggregate number in these occupations being 2,882,779. The total number of women reported as textile mill operatives—231,458—makes this the seventh occupation group in numerical importance. The occupation next in rank is that of housekeepers and stewardesses. This comprised 146,929 women. The housekeepers here referred to are those working for wages, the housekeeping or housework done by women in their own homes not being treated by the census as a gainful occupation, although it has, of course, a great economic importance not to be overlooked in any attempt to estimate the social value of woman's work. If there are added to the occupation groups already mentioned the group of saleswomen, comprising 142,265 women, and that of seamstresses, comprising 138,724, the list includes the ten leading occupations for women and accounts for 3,542,155, or 73.3 per cent, of the total number of women who are bread winners.

It is interesting to note that of these ten leading occupations, five, comprising the occupations of domestic servant, dressmaker, laundress, housekeeper, and seamstress, are what might be termed distinctly feminine pursuits. They represent work connected with the care of the family which was formerly done almost exclusively by women at home as part of their regular household duties, and although these occupations have now become to a considerable extent differentiated as professional pursuits they are still mostly in the hands of women.

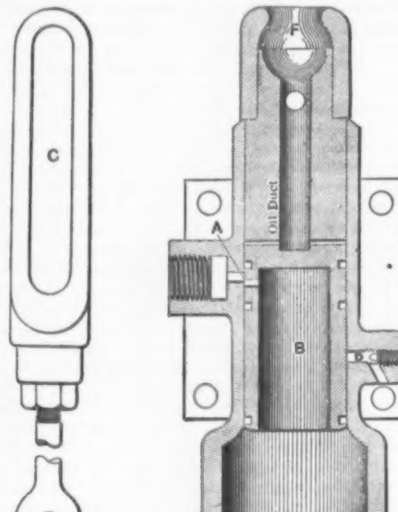
Teaching also is an occupation in which women predominate. The occupation is one in which both sexes have long been competing on terms of approximate equality, and it is significant that it is also one in which the predominance of women is increasing. In 1880 the percentage of female teachers was 67.8; it ad-

vanced to 70.8 in 1890, and to 73.4 in 1900. In the group of textile mill operatives the two sexes were represented in about equal numbers. But in the remaining thsee of the ten leading occupations mentioned above, women, though numerous, were in the minority, constituting 24.1 per cent of the total number of salesmen and saleswomen, 13.6 per cent of the farm laborers, and only 5.4 per cent of the farmers.

Detailed statistics of the women in each of the principal occupations for this sex are presented in the report, including classifications by age, race, nativity, marital condition, and family relationship.

SIMPLE LOCOMOTIVE BELL RINGER.

The Railway Master Mechanic illustrates and describes a simple locomotive bell ringer, which is operated by compressed air. The special features of ad-



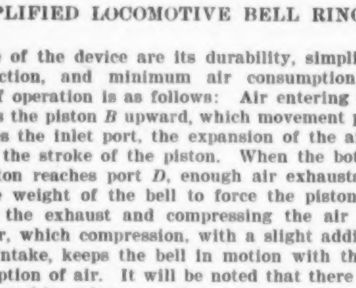
SIMPLIFIED LOCOMOTIVE BELL RINGER.

vantage of the device are its durability, simplicity of construction, and minimum air consumption. The mode of operation is as follows: Air entering at port *A* starts the piston *B* upward, which movement promptly closes the inlet port, the expansion of the air completing the stroke of the piston. When the bottom of the piston reaches port *D*, enough air exhausts to allow the weight of the bell to force the piston down, closing the exhaust and compressing the air in the chamber, which compression, with a slight addition of air at intake, keeps the bell in motion with the least consumption of air. It will be noted that there are no valves, packing rings or oil cups required, as oiling the ball bearing lubricates the piston through a small oil hole shown in the cut. At *C* the bell crank yoke is shown with its adjustable connecting rod and ball, the latter fitting in the socket *F*.

HOME-MADE LINEAR EXPANSION APPARATUS.*

By R. O. Austin.

Exclusive of the spherometer the cost is almost noth-



HOME-MADE LINEAR EXPANSION APPARATUS.

ing. Any piece of flat metal about 2 millimeters thick will answer on which to place the spherometer.

To save the trouble of putting in side tubes, two-hole rubber stoppers are used, one hole for the rod and one for the steam. The apparatus may be made of any convenient length. The steam jacket is about 25 millimeters in diameter. It is not necessary to use a thermometer to determine the temperature of the steam as this can be computed from the barometer reading.

* School Science and Mathematics.

THE MOST ECONOMICAL MEAN EFFECTIVE PRESSURE FOR STEAM ENGINES.*

By R. Royds.

The development of the reciprocating steam engine has been along the line of higher initial steam pressures. Cenerally speaking, the thermo-dynamic efficiency has increased as the steam pressures have been raised, owing chiefly to the increased temperature range from the steam chest to the condenser. It does not follow, however, that all modern steam engines are designed to utilize the available energy in the steam to the greatest advantage. The gain in economy obtained with the rise of steam pressures has somewhat obscured the conditions which make for maximum efficiency, for any type of engine using steam at any particular pressure. For an exact determination of the most economical conditions for any tybe of engine direct experiments are necessary. It is not sufficient to say that engine builders are bound to know the limits of performance for their engines by careful observations of the coal consumptions for different installations, because the conditions vary considerably in practice, and it is very difficult, if not impossible, to discriminate between all the variable elements which can influence the performance of a steam plant. Even when an engine is tested as regards its steam consumption it is not often at more than one or two loads, just to see that the guaranteed steam consumptions are not exceeded.

Dr. Mellanby, in summarizing the results of a series of tests made by him on a compound condensing engine,† said: "Compound condensing engines, with a boiler pressure of 150 pounds per square inch, may be worked with a mean pressure referred to the low-pressure cylinder of about 40 pounds per square inch, without any loss of efficiency in terms of brake horse-power." In the discussion following the reading of the paper there was only one engineer who agreed with Dr. Mellanby on this point, and, singularly enough, a member of a firm which is noted for the magnitude and elaboration of their experimental steam plant. The conclusion to be drawn from this is that the majority of engine builders do not know exactly the most economical or best mean effective pressures for their engines, given any particular conditions under which they have to work. Many look with contempt upon tests which give results differing from the commonly-accepted notions, saying that, although the results may be all right for the particular engine tested, they do not apply to their engines. There would not be any complaint against such an attitude if it were founded upon direct experimental evidence; but too often, I am afraid, the only reason for the existence of common notions is that many builders simply copy others. Let this subject be approached with an open and unbiased mind, and first consider the published results of a few tests on steam engines where the power has been varied by varying the cut-off, all other conditions having been kept as constant as possible.

From an analysis of the published experiments during the past twenty years, the author arrives at the following conclusions:

1. The higher the mean effective pressure the lower will be the first cost of a steam engine of any given power.

2. For multiple-expansion unjacketed condensing engines, using saturated steam at about 165 pounds per square inch absolute in the engine cylinder, the best mean effective pressure for normal load is from 40 pounds to 45 pounds per square inch referred to the low-pressure cylinder, and the economy varies but slightly for a considerable range in the mean effective pressure.

3. For jacketed multiple-expansion condensing engines with steam pressure as above, the best mean effective pressure is slightly lower than for unjacketed multiple-expansion condensing engines.

4. Non-condensing engines have a best mean effective pressure rather higher, and the variation in economy for any given range of mean effective pressure is less, than for condensing engines.

5. For steam pressures higher than 165 pounds per square inch absolute, the best mean effective pressure is higher than from 40 pounds to 45 pounds per square inch, and is probably as high as from 45 pounds to 50 pounds per square inch referred to the low-pressure cylinder, for triple or quadruple-expansion engines using saturated steam over 200 pounds per square inch boiler pressure.

6. Multiple-expansion engines using saturated steam below 165 pounds per square inch absolute have their best mean effective pressures below from 40 to 45 pounds per square inch, and this best mean effective pressure falls more rapidly with fall of steam pressure for the condensing than for the non-condensing engine.

7. The more economical an engine can be made, the lower is likely to be the best mean effective pressure, though not to any large extent. Hence large engines may have a rather lower best mean effective pressure than small engines using steam at the same pressure.

8. Engines using highly superheated steam, so that the steam is superheated during expansion, have a best mean effective pressure lower than for engines using saturated steam, with a consequent increase in first cost for any given power. Such engines, however, have a high thermal efficiency, and will maintain the same efficiency over a wide range of power.

9. The best mean effective pressure is about 35 pounds per square inch for single-cylinder condensing non-jacketed engines using saturated steam at about 75 pounds per square inch absolute. For other conditions the same general laws hold good as for multiple-expansion engines.

The most economical mean effective pressure is influenced slightly by the variation of first cost with variation of mean effective pressure, but no particular account has been taken of this. Also, the character of the load—that is, whether variable or fairly constant—will have an influence. For example, an engine which is subjected to frequent and long-continued overloads should have a lower mean effective pressure for normal load than a similar engine which is nearly always working at the normal load.—The Practical Engineer.

* Abstract of a paper read before the Institution of Engineers and Shipbuilders in Scotland, on March 19, 1907.

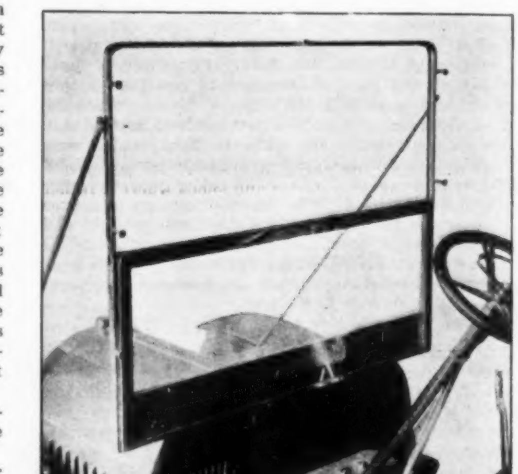
† Mellanby. Proc. Inst. of Mechanical Engineers, June, 1905. Page 554.

A NEW GLASS FRONT FOR AUTOMOBILES.

The automobile front shown herewith, instead of being built so as to fold over when it is not desired to use the whole front, is constructed like a window sash in such a manner that the upper part can be readily lowered, as shown. To lower the sash it is only necessary to release the spring buttons which press against it and clamp it firmly against the frame. It can then be readily dropped. Should rain come on and the protection be wanted again, the sash can be quickly raised while the car is in motion. The front has been placed on the market by the Studebaker Company, and it is one of the neatest and handiest automobile fronts that has thus far been invented.

SWALLOWS AS ALLIES OF THE FARMER.

The Biological Survey of the United States Department of Agriculture has hit upon a somewhat novel method of aiding the southern cotton planter in his war against the boll weevil. As is well known, this insect invaded the State of Texas several years ago and has damaged the cotton crop to the extent of millions of dollars annually. Despite efforts to stay



A NEW GLASS FRONT FOR AUTOMOBILES.

its increase, it is spreading at the rate of about 50 miles a year and unquestionably in time will extend its ravages into all the cotton States.

The Survey has been investigating the pest in Texas for several years and finds that no fewer than 38 species of birds feed upon the insect. It is not claimed that birds alone can check the spread of the weevil, but it has been demonstrated that they are an important help which the farmer cannot afford to ignore. Hence an appeal is made to the northern farmer to aid in the work on the ground that the insect enemy of the farmer of every district is the common enemy of the country, and that a full measure of success is to be obtained only through co-operation. The importance to the cotton planter also of colonies of swallows is emphasized, and the best means of increasing their number in the Southern States is set forth.

Among the foremost of the useful allies against the boll weevil are swallows. As is well known, the food of these birds consists almost exclusively of insects, and hence to the agriculturist they are among the most useful of birds. They have been described as "the light cavalry of the avian army." Specially adapted for flight, they have no rivals in the art of capturing insects in midair, and it is to the fact that they take their prey on the wing that their peculiar value to the cotton grower is due.

Other insectivorous birds adopt different methods when in pursuit of prey. Orioles alight on the cotton bolls and carefully inspect them for weevils. Blackbirds, wrens, and flycatchers contribute to the good work, each in its own sphere, but when swallows are migrating over the cotton fields they find weevils flying in the open and wage active war against them. As many as 47 boll weevils have been found in the stomach of a single cliff swallow.

The idea is to increase the number of swallows both

at the North and the South. The colonies nesting in the South will destroy a greater or less number of weevils during the summer; while in the fall, after the local birds have migrated, northern-bred birds, as they pass through the Southern States on their way to the tropics, will keep up the war.

Swallows are not as numerous in the North as they used to be. The tree swallow, for instance, formerly abounded, but of late years its numbers have greatly diminished, owing to persecution by the English sparrow. This unscrupulous foreigner turns the swallow out of its nest in order to have a place for its own eggs. When swallow nests contain eggs or young, the murderous sparrow kills the helpless nestlings or throws out the eggs.

The barn swallow also is diminishing in numbers, owing partly to enmity of the sparrow, but more, perhaps, to the fact that the modern tightly built barn denies it friendly shelter, and it finds no substitute places in which to nest. The cliff swallow, whose curious pouch-shaped mud nest used to be a common sight under the eaves of barns and outbuildings throughout the Northern States, has now been entirely banished from many localities under the mistaken impression that they are undesirable neighbors because of certain parasites which infest their nests. These have been supposed to be bedbugs, and hence the nests have been destroyed and the birds driven away. This is an error, for, although related to the above objectionable insect, these swallow parasites are peculiar to birds and are not to be feared by man.

Of all the swallows the martin is considered the most important to the farmer, and suggestions are given for increasing its numbers by the erection of additional boxes and of increasing its range by the transportation to new localities of boxes containing old birds and half-grown young, in the belief that the old birds will be induced by the presence of their young to remain and feed them. If they do not, the only alternative is bringing the young up by hand, which has been successfully done by feeding them meal worms, grasshoppers, and the like.

Migratory birds—and most American birds are migratory—are the property of the nation rather than of individual States, and co-operation between the several States for the preservation and increase of insectivorous birds is a principle worthy of universal adoption.

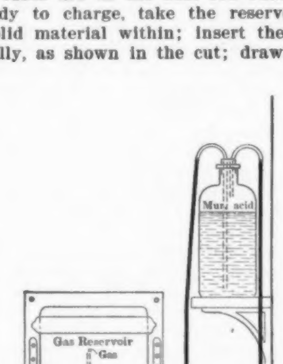
A SIMPLE GAS GENERATOR FOR LABORATORY USE.*

By W. M. MILLS.

THE accompanying cut illustrates a new gas generator, suitable for laboratories and shops where a rather large amount of a gas may be required at any time on short notice. Almost any gas needed may be generated here, the one apparatus doing for all. Sulphureted hydrogen (H_2S), carbonic acid gas (CO_2), and hydrogen (H), however are the ones most required.

The reservoir is made from an old carboy (about 5 gallons) or a smaller one may be had from druggists (about 3 gallons). It is inverted and mounted on a suitable shelf fastened firmly to the wall, so the operator may get at the neck and mouth readily. The acid bottle is mounted, as shown, on a shelf higher up and filled with dilute commercial muriatic acid about three-fourths full. A small bicycle pump is used to start the acid over. The safety bottle is found essential to filter and strain the gas from minute particles which might damage analytical work. All glass parts are necessarily strong, the tubes being at least ¼-inch bore. The rubber tubes are of the best red rubber.

When ready to charge, take the reservoir down; place the solid material within; insert the cork and tubes carefully, as shown in the cut; draw the parts



IMPROVED GAS GENERATOR.

up tight with wire; replace it on shelf, and connect it up. Only one or two strokes of the pump are necessary to start the apparatus. Discard the first ten seconds' flow of gas as contaminated; the rest will be pure. When sufficient quantity has been drawn off, turn the stopcock. The expansion of gas in the reservoir will expel the acid back into the bottle. Any excess of gas will bubble out of the top of the bottle, and for this purpose the rubber cork there must be loosened when the stopcock is turned. The author has never elsewhere seen or heard of this device for generating gas, but has observed in colleges and universities a very much inferior sort, nearly all of which were continually out of order. Most of them were quite expensive as well. The present apparatus has been in use for three years in the chemical laboratory of the writer, and only one charge per year was necessary.

* Specially prepared for the SCIENTIFIC AMERICAN SUPPLEMENT.

IONIC THERAPEUTICS.

WHEN an electric current traverses a solution of a salt the latter is decomposed, the metal appearing at

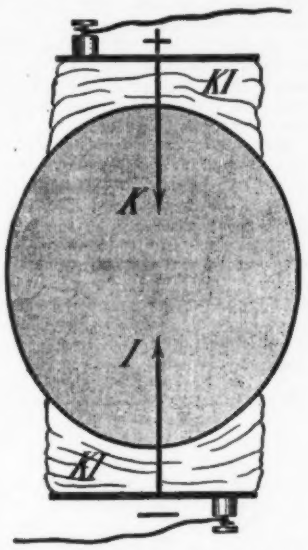


FIG. 1.—DIAGRAM ILLUSTRATING THE MOVEMENTS OF IONS THROUGH A HUMAN BODY.

The spongy electrodes on opposite sides of the body are saturated with potassium iodide (K I). Potassium (K) enters the body from the anode above, and iodine (I) enters from the cathode below as indicated by the arrows.

the negative pole or cathode and the acid radical at the positive pole or anode. Such a solution is called an electrolyte. Acids and alkalies are likewise electrolytes. Acids may be regarded as salts in which the metal is hydrogen, and alkalies as salts in which the acid is hydroxyl, OH.

Faraday gave the name ions (from the Greek *io*, to go) to the constituents of the electrolyte which appear at the electrodes and distinguished the anion (Greek *ana*, up) disengaged at the positive pole from the cathion (Greek *kata*, down) which appears at the negative pole.

The tissues of the human body are impregnated with saline solutions. They may therefore be regarded as electrolytes, and the electric conductivity of the body is an electrolytic conductivity.*

When an electric current passes through the human body the electrolytic molecules, most of which are molecules of sodium chloride, are dissociated, the electro-negative chlorine going to the positive electrode, or anode, and the electro-positive sodium to the negative electrode, or cathode. If the electrodes are of platinum or other substance which is not attacked by the ions, the anion chlorine, after giving up its negative electric charge to the anode, combines with some of the hydrogen of the watery tissues in the immediate vicinity, thereby partly destroying them, forming hydrochloric acid and setting free oxygen by a reaction which may be written: $2Cl + H_2O = 2HCl + O$. The electrolysis of living tissues, which has long been used in medical practice, is based on this process.

Let us suppose that it is desired to remove a small vascular tumor by electrolysis without leaving noticeable scars. A needle or a number of needles of gold or platinum, covered except at the point with insulating varnish, is thrust into the tumor. A current is then passed through the body, between these needles as the anode and a large and chemically inert cathode consisting, for example, of a bath of salt water in which the patient's hand is immersed. Under these conditions chlorine is evolved at the anode causing intravascular coagulation and partial destruction of tissue, while the sodium which is set free at the cathode simply dissolves in the salt water without exerting any important effect upon the tissue of the hand. This is a typical example of medical electrolysis as formerly practised.

But the action is altogether different if the electrodes consist of solutions of salts, acids or alkalies. In this case the passage of the current effects ionic exchanges between the body and the electrodes.

For example, if the electrodes are spongy substances saturated with a solution of potassium iodide, the potassium, which is a cathion, will traverse the skin and the tissues in the direction from the anode to the cathode, while the anion iodine will enter the body at the cathode and travel in the opposite direction.

FIG. 3.—IONIC THERAPEUTICS IN FACIAL NEURALGIA.

The active negative electrode is applied to the face, the inactive positive electrode to the leg. A, B, Metallic plates attached to the conducting wires. C, C, Absorbent layers saturated with electrolytic solutions.

This simple phenomenon may give rise to a revolution in therapeutics. Until recently it was believed that only an insignificant quantity of medicinal substances, or none, could be introduced into the body by means of the electric current, but it is now known that such introduction can be effected easily and regularly so as to produce at will local effects on the skin or general therapeutic or poisonous effects throughout the body, according to the electrolytic solution employed, the intensity of the current and the length of time during which it is applied.

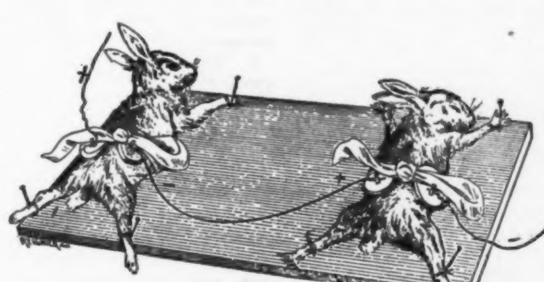
Dr. Leduc has proved this by numerous experiments, of which we here describe three, performed in our presence, and afterward repeated by ourselves.

When electrodes saturated with potassium permanganate are placed in the ears of a rabbit, and the current is applied for a sufficient time, the inside of the ear which contained the cathode is found to be marked with uniformly distributed brown dots which can not be removed by washing. These dots consist of manganese oxide, the negative ion resulting from the electrolytic partition of the molecule of potassium permanganate, and the oxide has been driven into the subcutaneous glands by the negative charge of the cathode. No marked change is observed in the inner skin of the other ear which was in contact with the anode.

If the cathode is a solution of potassium cyanide, death quickly ensues, but potassium cyanide at the anode produces no such effect.

On the other hand, strychnine sulphate employed as the anode soon produces characteristic tetanic convulsions and death, but the same solution is ineffective when used as the cathode.

To demonstrate the effect of the direction of the current, Dr. Leduc has devised the following elegant and instructive arrangement. The current is caused to



First rabbit. Second rabbit.

FIG. 2.—TWO RABBITS TRAVERSED IN SERIES BY THE SAME CURRENT PASSING THROUGH ELECTRODES OF STRYCHNINE SULPHATE AND SODIUM CHLORIDE.

* Stéphane Leduc: Les nouvelles théories des solutions dans leurs rapports avec la médecine. Les Ions, les médications électrolytiques. Published in La Presse Médicale, Nos. 70, 72, 74, 76, September, 1906.

flow through two rabbits arranged in series. The electrodes consist of tufts of absorbent cotton saturated with solutions of strychnine sulphate and sodium chloride and placed in contact with plates of metal attached to the conducting wires. The exterior electrodes through which the current enters the first and leaves the second rabbit are saturated with sodium chloride. The interior electrodes, through which and a short wire the current passes from one rabbit to the other, are saturated with strychnine sulphate. As strychnine is a cathion it moves toward the cathode. Hence strychnine ions penetrate the body of the second rabbit which soon succumbs to convulsions. But the strychnine which is in contact with the first rabbit is already at a cathode. Consequently it does not enter the body of the animal, which remains unaffected.

These methods are applicable to the human subject and make it easy to introduce definite medicinal ions. Dr. Leduc has cured facial neuralgias in which repeated surgical operations had proved ineffective by the electrolytic introduction of salicylic acid into the diseased part.

One of the most regular therapeutic effects of electrolytic treatment is its resolvent action on hardened tissues and scars. For this purpose a solution of sodium chloride is employed as a cathode. Dr. Leduc cites the case of a young soldier whom an abscess in the hand had left with complete anchylosis or immobility of the fingers. In a military hospital the patient had received without benefit various treatments, including forcible working of the joints under chloroform, and had finally been discharged as incurable. He was then treated by electrolysis. The injured hand was immersed in a bath of salt water which served as the cathode, and a current of 0.03 ampere was applied for half an hour. Two such treatments effected a complete cure. The writers have also obtained remarkable and very rapid cures in cases of stiffness of the joints caused by wounds. Electrolytic medication is still in its infancy, but it seems destined to have a great future.

In the words of Prof. Leduc: "It is difficult to imagine how absurd will appear in the future our present practice of disseminating throughout the body, in order to act upon a very small region and a coarse tissue, substances which are particularly injurious to the most delicate and important tissues, such as those of the nervous centers. It should be one of the objects of medicine to substitute local for general treatment whenever it is possible to do so. Toward the attainment of this object the electro-ionic method offers means, not presented by any other system of medication. It enables us to introduce into cells impermeable to many drugs, the entire series of ions and to obtain the specific effect of each."—From the French of Drs. P. Desfosses and A. Martinet in La Nature.

PREVENTION OF FREEZING IN CONCRETE BY CALCIUM CHLORIDE.

By Richard K. Meade.

Probably each winter finds more and more concrete work being done. The importance of protecting such work from freezing and thawing is well understood, and it is now the general practice either to heat the sand, gravel and water used in making the concrete or else to add salt to it. Heating the water and aggregate hastens the setting of the mortar and staves off the freezing, by the initial heat of the mixture, until after the concrete has hardened. In the other case the salt being dissolved by the water used in the making of the mortar, forms a brine which freezes at a lower temperature than does pure water. The first method is expensive, troublesome and in large undertakings almost an impossibility. The second method is, therefore, the one usually resorted to for preventing freezing.

Now it is a well-known fact that solutions of calcium chloride freeze at a much lower temperature than do solutions of salt of the same degree of concentration. For instance, a 20 per cent solution of salt freezes at 7 deg. F., while a 20 per cent solution of calcium chloride does not freeze until the temperature falls 8 deg. lower, or to —1 deg. F.; calcium chloride should, therefore, be much more effective than salt in preventing the freezing of cement mortar. Additions of salt to concrete have no other beneficial effect than to prevent freezing, while calcium chloride in small percentages is known to often cause unsound cement to become sound and also to render cement mortar more impervious to water.

In view of these facts, it seemed an important matter to investigate the effect which calcium chloride exercises in preventing the freezing of mortar exposed to low temperatures. At the beginning of the cold weather of the present winter, therefore, the writer undertook a series of experiments along that line, the results of which follow:

Strength.—In order to investigate fully the strength of Portland cement mortars, with and without addition of calcium chloride, when exposed to cold weather, ten sets of sand briquettes of ten briquettes each were made up as follows:

Sets.	Cement.	Sand.	Calcium Chloride, Per Cent.
2	1	2	0
1	1	2	2
1	1	2	4
1	1	2	6
2	1	3	0
1	1	3	2
1	1	3	4
1	1	3	6

The sand used was standard crushed quartz and the cement was of a standard American brand, about two weeks old and normal in every respect. It passed both the steam and boiling tests and left a residue of 4 per cent on a No. 100 test sieve. It took its initial set in 2 hours and its final set in 5 hours and 15 minutes.

The calcium chloride used was obtained from the Carbondale Chemical Company, Carbondale, Pa., and was marked Solvay Process Company's Chloride of Calcium and guaranteed by them to contain 75 per cent anhydrous salt, $CaCl_2$.

Of the ten sets of briquettes, two, one 1:3 mortar and one 1:2 mortar, both containing no chloride, were tested in the ordinary standard manner, by leaving them in the laboratory for 24 hours under a damp cloth and then placing them in water for the balance of the 7 and 28-day periods, this being merely the standard test to determine the strength the cement was capable of developing under standard conditions.

The other eight sets were carried out of doors as soon as made. They were placed on a porch roof, on the northwest side of a building, and exposed to whatever the elements had in store for them. The morning after they were made they were covered with snow and this was cleared away to remove its protection from the wind. The range of temperature is shown in Table I. for the entire 28 days. The "first day" is the day that the 1:3 sand briquettes were made and taken out of doors, and the temperature given as the maximum is that to which they were first exposed. The 7-day 1:3 briquettes were broken on the eighth day and the 28-day 1:3 briquettes on the 29th day. The 1:2 sand briquettes were made and exposed on the second day and broken on the ninth day and thirtieth day, respectively.

Table 1.—Temperatures to Which Briquettes Were Exposed.

Day.	Max.	Min.	Day.	Max.	Min.
1st	35		18th	24	14
2d	38	19	19th	25	13
3d	35	18	20th	17	5
4th	23	15	21st	29	—1
5th	31	13	22d	27	10
6th	12	—1	23d	27	3
7th	15	—4	24th	35	20
8th	26	8	25th	29	25
9th	25	22	26th	28	12
10th	18	6	27th	39	23
11th	23	8	28th	38	13
12th	30	5	29th	47	30
13th	34	22	30th	44	15
14th	23	5	31st	28	13
15th	38	12	32d	26	13
16th	43	30	33d	21	8
17th	23	17	34th	26	16

The 7-day 1:3 briquettes were exposed to temperatures as shown between the first and eighth days, and the 28-day 1:3 briquettes to the temperatures indicated between the first and twenty-ninth days, etc.

It will be seen that the effect of the addition of 2 per cent of calcium chloride was to make the cement mortar exposed to the cold as strong as that kept in a warm room, 60 deg. to 70 deg. F. This is no doubt due to the fact that calcium chloride prevents the freezing of water to which it is added and so, when it is mixed with the cement it is taken up by the water used to gage the mortar, preventing the freezing of this water and consequently allowing the processes of solution and crystallization, which constitute the hardening of cement mortar, to go on without hindrance by the freezing of the water.

The power which calcium chloride can exert to prevent the freezing of mortar may be understood from the following explanation. About 10 to 15 per cent of water is used in making concrete. If all the calcium chloride dissolves in this, and since it is very soluble there is reason to believe that most of it does, a 15 to 20 per cent solution of the salt will be formed and the freezing point of such a solution is 14 deg. to —1 deg. F.

The maximum effect seemed to be reached with 2 per cent calcium chloride, and this amount was sufficient to increase the strength of the mortar approximately one-third over that of mortar not protected from freezing. The larger proportions of chloride did not seem to exercise the same influence as 2 per cent. This was no doubt because additions of both 4 per cent and 6 per cent caused marked quickening of the setting time of the cement used. It is a well-known fact that quick-setting cement does not show as high strength as the slow-setting. It is a curious fact, although well known, that up to a certain point additions of calcium chloride retard the setting of cement, but beyond this amount they have the opposite effect.

About a week after the first lot of briquettes were made, a very cold spell of weather came and it was deemed advisable to make up a new lot of briquettes and expose to this extreme cold. Four sets were made up of 1:3 cement and sand mortar containing respectively 0 per cent, 2 per cent, 4 per cent, and 6 per cent calcium chloride. Sand, cement, and molds were all chilled to out-of-doors temperature and the water was drawn from the tap, in this experiment. The briquettes were then placed out doors as soon as made. The temperature at that time being 5 deg. F., or 27 deg. below the freezing point of water. The temperature dropped to —1 deg. F. that night. The temperatures to which these briquettes were subjected is shown in Table 1. They were placed out of doors on the fifth day and the seven-day and twenty-eight-day briquettes were broken on the twelfth and thirty-third days, respectively. The tensile strength of these briquettes is shown below in Table 3:

Table 3.—Strength of 1:3 Mortar Exposed to 5 deg. Temperature as Soon as Made.

Age	7 days				28 days			
Chloride	0%	2%	4%	6%	0%	2%	4%	6%
	139	225	218	192	236	408	325	258
	142	215	226	174	215	388	328	270
Individual	128	236	200	194	220	376	350	280
Breaks.	140	221	2[illegible]	180	218	378	342	263
	121	229	196	202	236	385	347	266
Average	135	225	208	189	225	387	338	267

It will be seen that the briquettes to which 2 per cent calcium chloride had been added were more than two-thirds again as strong as those to which no calcium chloride had been added, showing that the colder the weather the greater the benefit that will be derived from the addition of calcium chloride.

In order to investigate the effect of alternate freezing and thawing upon the strength of cement mortars made with and without calcium chloride, four sets of cement mortar (1 of cement to 3 of sand) were made with 0 per cent, 2 per cent, 4 per cent, and 6 per cent calcium chloride, respectively. These were placed out of doors as soon as made and allowed to remain out over night. The thermometer fell as low as 4 deg. F. that night. In the morning they were brought into the laboratory and allowed to remain all day, the temperature reaching 72 deg. F. while they were in the room, or a change in temperature of 68 deg. F. Each night these briquettes were placed out of doors, and each morning they were brought in the house. In this manner they were exposed to alternate freezing and thawing daily for the whole of the first seven days and practically all of the 28 days. The strength of the briquettes so exposed is given in Table 4.

It will be seen that in this instance also the mortar containing 2 per cent calcium chloride had about one-third greater strength than the mortar to which no chloride had been added.

Table 4.—Strength of 1:3 Mortar, Alternately Frozen and Thawed.

Age	7 days				28 days			
Calcium chloride	0%	2%	4%	6%	0%	2%	4%	6%
	247	318	325	302	313	379	359	351
	230	328	323	324	302	391	350	354
Individual	244	317	313	318	316	396	358	323
Breaks.	244	343	313	310	321	412	371	328
	231	340	306	304	290	414	362	352
Average	239	329	316	312	308	398	360	342

Color.—In order to determine the effect which calcium chloride would have on the color of the cement, and also to see if efflorescence occurred in concrete made with this, with a view to determining if calcium chloride could be used in making hollow concrete blocks during the winter time, small slabs of concrete 8 inches square were molded of 1:3 mortar. These blocks were allowed to dry out in the room, and also were alternately sprinkled and dried with a view to bringing out efflorescence. The slabs containing 4 per cent and 6 per cent calcium chloride, on drying out for the first time, showed considerable efflorescence; but this washed off when the slab was sprinkled and did not reappear. There were also apparent in the blocks small dark splotches with white borders, due no doubt to the caking of the chloride and consequently to its not having been thoroughly disseminated through the mortar. This was overcome by dissolving the calcium chloride in the water used for the mixture. When this was done the slab of mortar made by adding 2 per cent calcium chloride could not be distinguished from that containing none, after both had dried out. The slab containing calcium chloride, however, owing to its affinity for water, took longer to dry, and conse-

Table 2.—Tensile Strength of Mortar with and without Calcium Chloride Under Different Conditions.

	Individual Breaks, 1:2 Mortar.										Average	
Age of briquettes, days	7	28	7	28	7	28	7	28	7	28	7	28
No chloride, tested in laboratory	412	527	394	531	392	516	410	548	398	538	401	532
No chloride, outside exposure	314	409	323	402	318	387	307	400	303	391	313	398
2 per cent chloride, outside exposure	404	500	416	516	430	502	399	511	421	521	414	510
4 per cent chloride, outside exposure	338	432	315	401	327	406	317	421	323	420	324	416
6 per cent chloride, outside exposure	367	462	359	430	350	441	350	432	361	444	357	442
	Individual Breaks, 1:3 Mortar										Average	
No chloride, tested in laboratory	280	360	278	364	292	372	290	360	287	352	285	362
No chloride, outside exposure	190	305	207	293	220	280	217	310	214	302	210	298
2 per cent chloride, outside exposure	404	500	416	516	430	502	399	511	421	521	414	510
4 per cent chloride, outside exposure	266	307	254	287	260	284	282	290	277	294	268	292
6 per cent chloride, outside exposure	284	287	284	297	271	281	264	306	262	280	273	290

quently looked darker, for the first week or two, than did the other.

Waterproofing Properties.—Some time ago the writer discovered that additions of calcium chloride helped to make mortar more impervious to water. In order to test this the slabs mentioned above were dried in the air for two weeks and placed on edge in a vessel containing about an inch of water and allowed to remain in this 24 hours. The slabs were weighed before being placed in the vessel and after being taken out and the surface water wiped off. The block containing no calcium chloride had absorbed 7.5 per cent of its weight of water, while that containing 2 per cent only 3.7 per cent of its weight of water. This shows that calcium chloride lessens the permeability of mortar more than 50 per cent, or, in other words, that a block containing no calcium chloride will absorb twice as much water as one having 2 per cent calcium chloride.

In this particular test, at the end of 24 hours, the slab containing no calcium chloride was wet all over while those having 2 per cent and over had their upper edges still dry. The slab containing 4 per cent calcium chloride absorbed 3.42 per cent water and that containing 6 per cent 3.40 per cent.

Soundness.—It is a fact well known that additions of calcium chloride will often render unsound cement sound. To several samples of unsound cement 2 per cent calcium chloride were added and in each case the resulting mixture passed the steam and boiling tests perfectly.

Conclusions.—From the above tests and experiments the writer has come to the conclusion that additions of calcium chloride to mortar, which is to be exposed to cold weather, will prevent its freezing and allow it to develop its full strength. That mortar to which it has not been added, when so exposed, will not develop its full strength, and in some instances has even insufficient strength to admit of its being used in work of any importance or strength.

That it may be used in concrete blocks which are made in the winter time, adding to their strength and impermeability, without causing discoloration of, or efflorescence on, the blocks.

That the addition of 2 per cent of calcium chloride will cause quick-setting cements to become slow-setting and often unsound cement to become sound. It is sometimes necessary to quicken the set of cement. When this is desired, calcium chloride, in the proportions of 4 or more per cent of the cement, can most safely be used since caustic soda and carbonate of soda both may cause cement mortar to expand and crack.—The Engineering Record.

THE DEMOLITION OF THE GREAT WHEEL AT EARL'S COURT, LONDON.*

The demolition of the Great Wheel at Earl's Court, which for twelve years has formed so conspicuous a feature of the London landscape, is completed. The work has been one requiring the exercise of no little ingenuity in the devising of safe, yet reasonably economical, methods of procedure. The efficiency of the arrangements made is well shown by the fact that in spite of an unusually severe winter, and in spite of the fact that unexpected difficulties arose in taking apart joints and withdrawing bolts and pins, the whole gigantic structure has been razed to the ground in a period of less than four months' actual working time, and without the occurrence of any serious accident directly attributable to the operations in progress. There was, it is true, one fatality; but this occurred at a time when work had been suspended owing to the violence of the wind, and the incident well illustrates how such lamentable occurrences will take place in spite of the utmost care on the part of the engineer and the contractors. The unfortunate victim in passing under the tower with a friend was struck by a pin falling from a shackle 150 feet above ground level. The pin had been loosened by the action of the wind in banging the shackle against the steel work. By an extraordinary fatality the workman thus so haplessly struck down had taken part in all the really dangerous portion of the work—that is to say, in the removal of the uppermost segments of the wheel; but when progress had been carried down to axle level, feeling less certain of his nerve, he had asked for a job on ground level, a request which was immediately complied with. This change of occupation was undoubtedly the indirect cause of the unfortunate man's death, as, when hit by the falling bolt, he was taking his friend to see the work on which he had just been engaged.

The wheel was a pin-jointed structure 300 feet in diameter, weighing, with the cars in position, about 1,000 tons, while the two four-legged standards on which it was mounted weighed about 400 tons more. No detailed plans of the edifice were available, and all the data necessary for determining the proportions and positions of the temporary struts required in the demolition had to be measured from the structure itself. For its erection very heavy and expensive scaffolding extending up to the axle level had been employed, but considerations of time and expense made impracticable any similar plan of operations for taking it down. The difficulties were enhanced by the very restricted area of the site on which the wheel stood. This site was in an angle between two lines of railway, over one of which the outer edge of the wheel protruded. Heroic methods, such as destruction by dynamite, were accordingly out of the question, and the engineer had, therefore, to face the problem of a piece-by-piece process of demolition. In this, moreover, the greatest care had to be exercised to insure the safety of the ground staff. Every bolt and nut had accordingly to be lowered down in bags, since small articles dropped from a height of 300 feet or more cannot be depended on to fall vertically. The first process was the removal of the cars, which were forty in number, and weighed some 200 tons. These were hung from the main pins of the outer peripheries of the wheel, which, to this end, were extended cantilever fashion beyond the chords, of which they made the joints. This removal was effected in such fashion as never to allow the wheel to be more than the weight of one car out of balance. The procedure will be understood by reference to Fig. 1. The cars were, of course, taken off at the lowest point of the wheel. Car No. 1 being removed, the wheel was turned through 180 deg., and car No. 21 taken off. The next car to be removed was No. 11, and the fourth car No. 31. By proceeding step by step in this fashion the whole of the cars were, in the course of ten days' work, dismounted without, as already stated, the wheel being unbalanced during the process by more than the weight of one car.

In devising the plans for taking down the structure, the wheel was assumed to consist of two semicircular arches, the upper one of which rested on, and was supported by, the lower one, which, in turn, was suspended

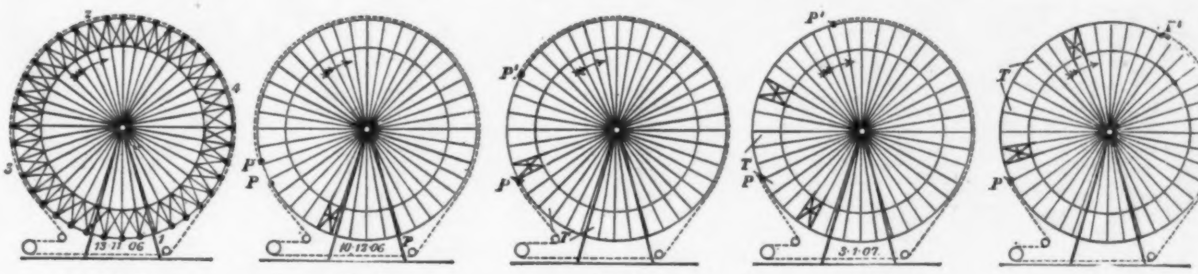


FIG. 1. FIG. 2. FIG. 3. FIG. 4. FIG. 5.

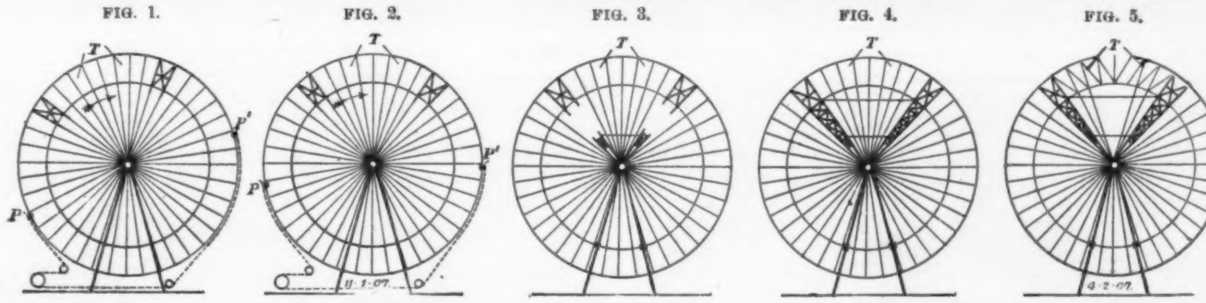


FIG. 6. FIG. 7. FIG. 8. FIG. 9. FIG. 10.

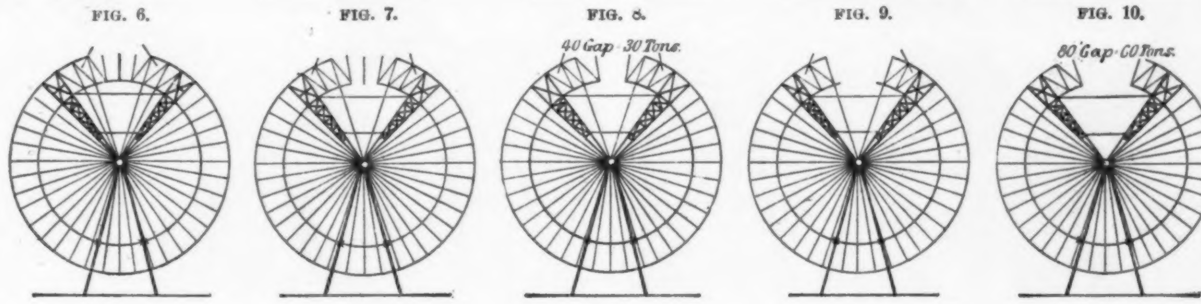


FIG. 11. FIG. 12. FIG. 13. FIG. 14. FIG. 15.

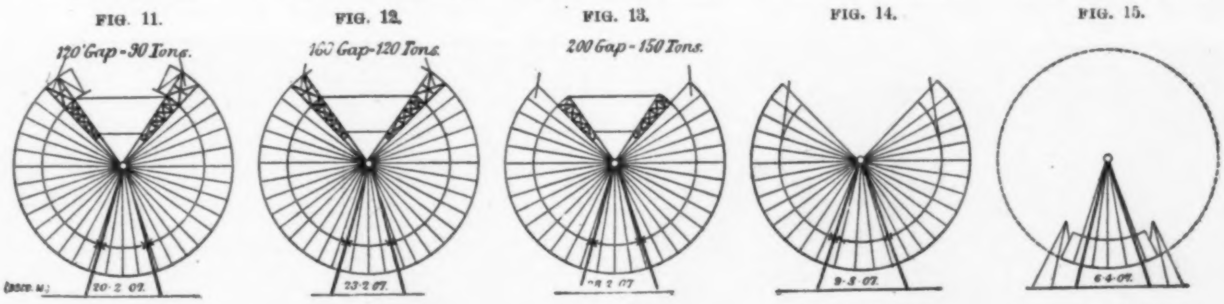


FIG. 16. FIG. 17. FIG. 18. FIG. 19. FIG. 20.

HOW THE FORTY CARS WEIGHING 200 TONS WERE REMOVED SO THAT THE WHEEL WAS NEVER OUT OF BALANCE MORE THAN THE WEIGHT OF ONE CAR.

THE DEMOLITION OF THE GREAT WHEEL AT EARL'S COURT, LONDON.

* Engineering (London).

from the axle. It was evident, therefore, that the wheel must be demolished from the vertex, and very careful consideration was given as to the safest and most economical fashion of effecting this. The matter of economy was indeed only less important than that of safety, since the purchasers intended to dispose of the metal as scrap. Calculation showed that if the vertex of the wheel were cut through, the amount of metal in the peripheries would be far from sufficient to withstand the heavy bending moments developed along the horizontal axis by the weight of the two cantilevers, then constituted by the upper quadrants of the wheel. The peripheries formed a pin-connected girder, about 40 feet deep. Each chord consisted of two members, built out of 5-inch by 4-inch by ½-inch angles, riveted by ⅞-inch rivets set at 4 inches pitch, to 7-16-inch web plates. These members were braced together by an angle-iron lattice work. Pin plates were riveted or bolted to each end of the web plates, the pins at the inner periphery being 5¼ inches in diameter, and at the outer 4¾ inches in diameter. Radial struts built up of 12-inch by 12-inch by ½-inch channels connected the inner and outer peripheries, and each bay of the complete girder was braced together by two steel diagonals 3¼ inches in diameter. Eighty steel spokes 2 9-16 inches in diameter connected the inner periphery to the axle, while another eighty spokes, crossed in plan, and 2½ inches in diameter, served as wind bracing.

Deep as was the circular girder constituted by the two peripheries, it was, as stated, not strong enough to take the stresses which would be developed on cutting through the vertex of the wheel, and it was determined, therefore, to insert two massive timber struts between the periphery and the axle, and to locate them in such a position that they could be removed with safety once the portion of the wheel between their upper extremities had been got rid of. These struts were built of 12-inch by 12-inch pitch pine timber, and were carefully laid out and erected on the ground, as shown in Fig. 21, before being put into position in the wheel.

Prior to this latter operation the wheel was tested for roundness, and was then discovered to be 2 feet out of truth at one point. It was determined, accordingly, to make this the point at which the peripheries were to be cut through, as in this way the truest portion of the wheel would be at the bottom, and a more regular distribution of the weight over the suspension spokes might be anticipated. The struts were designed to carry a load of about 100 tons, and their upper ends extended to a height of about 100 feet above the level of the axle. Each strut, which, as will be seen, was a composite structure, weighed about 20 tons. The process of putting them into place is clearly illustrated in Figs. 2 to 8.

Since the weight of the wheel was carried entirely by the spokes in tension, any point of the wheel was obviously always somewhat nearer the axle when at the top than when occupying its lowest position. It was considered best, therefore, to complete the building of the struts into place with the wheel occupying the final position at which the actual work of taking it to pieces was to be begun. Each leg of each composite strut consisted of three lengths of 12-inch by 12-inch pitch pine. The upper lengths were built in between the peripheries at a point near ground level, and were thoroughly braced together by wire ropes and cross-struts of timber. The upper end of the two struts being


FIG. 21.—TIMBER STRUTS ERECTED ON GROUND; DECEMBER 7, 1906.


FIG. 22.—UPPER END OF STRUT, SECURED TO WHEEL; JANUARY 10, 1907.

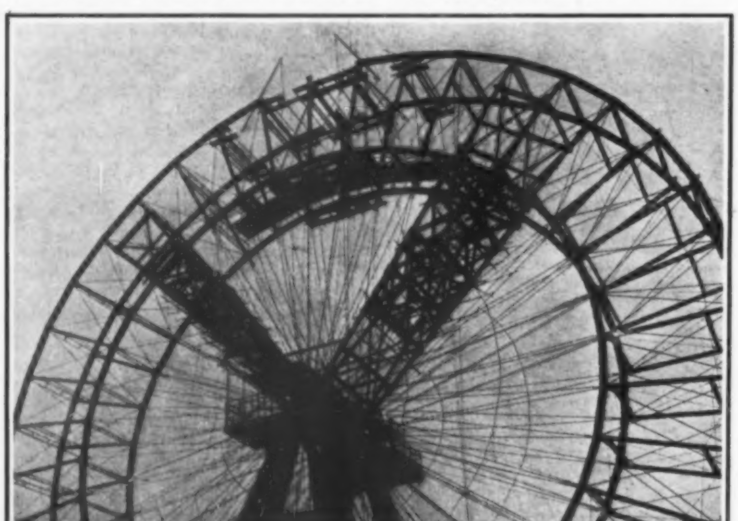


FIG. 23.—FIRST CUT IN PERIPHERY; FEBRUARY 6, 1907.


FIG. 24.—BUCKLED PRINCIPALS OF INNER PERIPHERY; FEBRUARY 11, 1907.


FIG. 25.—120-FOOT GAP; FEBRUARY 18, 1907.


FIG. 26.—200-FOOT GAP; MARCH 5, 1907.

THE DEMOLITION OF THE GREAT WHEEL AT EARL'S COURT, LONDON.

thus placed in position, the wheel was then turned round till the proposed point of disconnection was at the top of the wheel, and this done, the latter was securely lashed to the inner legs of the standards by wire rope. The procedure was as follows: The bay which was to take the upper end of one of the struts was brought near the lowest point of the wheel (Fig. 3), and this upper end was built into it. This done, the wheel was then moved round, to bring the proposed point of disconnection to the lowest point of the wheel, in which position the stagings and derricks to be used in removing the steel work at that point were fixed in position. The wheel was then moved on, to bring near the lowest position the bay which was to receive the upper end of the second strut, which was then fixed in the same manner, and the wheel turned round to bring the proposed point of disconnection into the topmost position, as indicated in Fig. 7.

During this series of operations, however, the cables used to operate the wheel were, bit by bit, got rid of, and lowered to the ground. These cables had an aggregate length of 2,100 feet, and weighed in all about 32 tons. While the upper end of the first strut was being fixed, these were got rid of in 60-foot lengths as the wheel was turned to its final position. These were first cut at the levels marked P and P^1 in Fig. 2, and as it was necessary to maintain the chain in tension on the driving sprocket, each of the ends was lashed to the wheel. The latter was then turned through about 60 feet, and the chain again lashed fast at the same level P, Fig. 3, and the piece of chain between P and P^1 was then cut off and lowered to the ground. The proposed point of section was then at the bottom of the wheel, and the derricks and staging to be used in removing the first segments were accordingly put into place as already mentioned. In Fig. 4 the wheel is represented turned through another 60 feet, when the chains were again lashed as before, and another 60 feet of cable cut off above the level P, and the top length of the second strut was secured in place with the wheel in this position. A further turn of the wheel is represented in Fig. 5, at which another 60 feet of cable was removed, and a similar length was cut away with the wheel in the position shown in Fig. 6. This progress in removal of the chain largely counterbalanced the weight added to the wheel by the fixing of the upper ends of the timber struts. In Fig. 7 the wheel has been moved round another 20 feet, and is in the position at which it was lashed fast, and the erection of the struts completed. At this point the remainder of the cable was cut loose and dropped to the ground. This diagram represents the state of affairs on January 11 last.

In Fig. 8 the lower portions of the struts are shown in position. These rested on box girders built out of ½-inch steel plate, specially constructed to rest on the axle, to which they were firmly secured. The upper ends of the struts being well braced together by wire rope, the distance between the opposing timbers was measured. The intermediate lengths were then cut to the dimensions found, less a clearance of 2 inches. The joint at one end of this intermediate section was made by splices of ½-inch steel plates, forming a box 4 feet long, inside of which the pitch pine principals were butted one against the other, the whole being secured by ⅞-inch bolts. Hardwood wedges were driven between the opposing ends at the other joint, so as to bring the struts fairly into bearing. It had been intended to grout up with neat cement the foot of each post, where it butted on the steel saddle on the axle; but by an oversight this was omitted, and when the full load came onto the struts, these settled down till they found a full bearing on the plating, the rivet heads burying themselves in the pitch pine.

The cross-bracing of the struts, consisting of timber posts and wire-rope ties, was next inserted, thus making all ready for the first cut. The condition of affairs was then that represented in Fig. 9.

In order to make certain that each man engaged in the difficult work involved in the removal of the upper segment of the arch should have a clear understanding of which bolts and rivets might be safely removed and which might not, such as those in tension, a wooden model of the upper part of the wheel was prepared, in which each joint, or portion of a joint, which was to be untouched was painted red. This model was explained to each individual workman, and not merely to the foremen, so that everyone had a thorough foreknowledge of the procedure to be followed. On February 4 the first cut was made in the continuity of the wheel, a set of plates being taken out from the outer periphery on each side of the top center, leaving the radial struts standing. The wind bracing, with the exception of two sets, was next removed, and in doing this the contractors and engineer themselves were confronted with an unexpected difficulty. It had been intended to drive out the pins at each joint, but owing to the effects of wear and rust this proved totally impossible. Indeed, it could seldom be done even after a member had been lowered to the ground level, and it was totally out of the question in the actual conditions under which the men had to work up aloft. Similarly, it proved equally impracticable to unscrew the sleeve couplings, with which certain of the tie bars were connected up. In fact, it was often necessary to cut off the nuts of the ⅞-inch bolts with which the pin plates were secured to the webs of the principals of the peripheries, since they proved intractable to the spanner. The whole of the tie bars and spokes had therefore to be sawn through with hacksaws, no other means existing of getting them out. Of these there were 160, each 3¼ inches in diameter, and a similar number of 2 9-16-inch and 2½-inch bars. The sawing had often to be done under rather awkward conditions, and it says much both for the skill and perseverance of the men and for the quality of the saws that the 3¼-inch bars were each cut through in about 2½ hours on the average.

FIG. 29.—THE DOWNFALL OF THE AXLE.

After the first plates had been removed from the outer periphery of the wheel, the weather became frosty, and much care had to be taken in proceeding with the operations on the inner peripheries, since these were under considerable thrust, as the full load had not yet come on the timber struts. It was originally proposed to take the thrust by a couple of 20-ton jacks, and then to remove the chords, after which the two opposing ends could be allowed to settle in gently toward each other, the movement anticipated being about 2 inches. An an experiment, however, it was determined to remove some of the bracing between the side plates of each principal forming the inner periphery of the bays under demolition, in the hope that if these plates crippled under the thrust, they would do so quietly, and thus let the wheel settle down in the gentle manner desired. These bracings removed, the men were withdrawn, lest in the bending of the plates a rivet should shear, its head fly off, and cause an accident. In less than half an hour after the men had left the work the plates were observed to quietly buckle in, to the shape of the letter S, coming about 1 foot 8½ inches out of line in a distance of 30 feet. The buckling of these plates is clearly visible in Fig. 24 which is reproduced from a photograph taken a few days later.

The load being now transferred to the timber struts, work could safely be resumed. The bent plates in question were not removed at once, but further weight was first taken off the outer peripheries, together with another 10 tons of the steel tie bars; the condition of the wheel on the completion of this work being represented in Fig. 11, while Fig. 12 represents the wheel with the whole of the chord members of the first two bays removed, leaving the two cantilevers, with the radial strut slung in the center. The lowering of this left a gap of 40 feet at the apex of the wheel. The weight removed in these operations was about 30 tons. In Figs. 14 and 15 the removal of another bay on each side of this gap is represented; and in Fig. 16 two more bays are gone, while in Fig. 17 the gap has been widened to 160 feet by the removal of 120 tons of material. The taking away of another 30 tons brought the scene of operations down to the upper ends of the temporary struts, leaving a gap of 200 feet between the ends of the outer peripheries. Although every bolt head had to be lowered over 300 feet, the whole of this difficult series of operations took but twenty-four days to accomplish. The struts, having now served their purpose, were next taken to pieces, and lowered from a steel hawser slung across the gap. This hawser, at the same time, assisted in steadying the wheel against wind pressure.

The condition of affairs after the removal of these struts is represented in Fig. 19. It will be seen that there was then very little overhanging weight to cause bending strains in the periphery. Portions of the dismantled struts were used to form the derricks, 70 feet in length, shown in position in Fig. 28. These were slung from the framework of the standing portion of the wheel, and could be swung through considerable angles when necessary. Being 12-inch by 12-inch pitch pine timbers, they were capable of sustaining very heavy loads, so that from this point on the chord members and radial struts were sent down intact, instead of being removed piecemeal. With their aid work was rapidly pushed forward, in spite of occasional stoppages from fog and wind. An equal rate of progress was maintained on each side of the wheel, so as to keep it well in balance. The derricks were lowered as the work proceeded, until at length the work of demolition reached the points at which the wheel was lashed to the standards. The derricks were then dispensed with and the whole of the remainder of the wheel dropped bodily to the ground by sawing through the suspension bars at the axle. This was done on April 11. The weight of the bays involved was about 60 tons, and the lowest point was about 18 feet above ground level. The upper ends of the suspension rods had, however, of course, to come down over 150 feet. The operation formed a very effective display, the combination of noise and twisting rods being like a miniature storm, accompanied by what may be termed "rod lightning." The time taken up to this point from the making of the first cut in the periphery of the wheel was only two months, and the condition of affairs at this stage is represented in Fig. 20. The next important step was to get the axle and its plummer blocks to the ground. The axle was 8 feet in diameter and about 40 feet long, and taken together with its plummer blocks, weighed about 60 tons. It was situated at a level of 180 feet above the

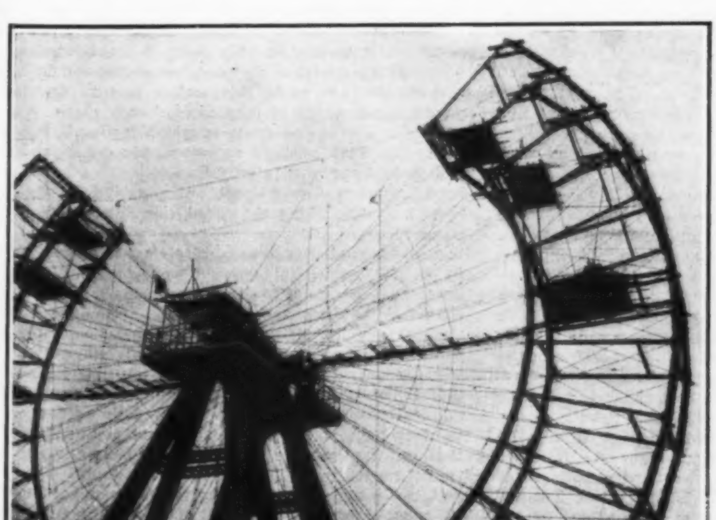


FIG. 27.—TIMBER STRUTS REMOVED; MARCH 9, 1907.

FIG. 28.—PITCH-PINE DERRICKS IN PLACE; MARCH 19, 1907.

THE DEMOLITION OF THE GREAT WHEEL AT EARL'S COURT, LONDON.

ground. After careful consideration, it was decided to throw the whole mass bodily to the ground, taking due precautions to cushion the blow on striking. This noteworthy feat was successfully accomplished, and in Fig. 29 we reproduce a photograph which shows the mass in mid-air.

The operation was accomplished by first jacking up the plummer blocks to a height of 3 inches above their beds, so as to get in underneath six round steel bars, 2½ inches in diameter, intended to serve as rollers. They were spaced at about 18-inch centers. Four steel-wire ropes, 2½ inches in circumference, were made fast to one end of each block and led over a pulley secured at the opposite end of the standards, on which the bearings rested, and thence to the ground. The lower ends of these wire ropes were coupled up to tackle, of sufficient strength to give a horizontal pull of 30 tons on the block at the top.

Owing, as was afterward ascertained, to a rivet having started in the upper plating, which prevented the motion of one of the rollers supporting the block, this pull proved insufficient to shift the corresponding end of the axle, though the other moved easily enough. The tackle at the obstructed end, however, broke repeatedly, and it was only after six hours' perseverance that success was attained. The refractory mass then went with a jerk, being actually flung off to an accompaniment of fire and smoke arising from the friction generated. At the moment of hitting the ground the mass had a striking energy of nearly 11,000 foot-tons, but the blow was received on a cushion of wood chips about 12 feet in thickness, which was thickly covered by tarpaulins to prevent the flying of splinters. Through this mass the axle penetrated, burying itself some 4 feet in the ground below.

The eight legs are now being removed. They are of box girder section, 4 feet square, built up of plates and angles. They weigh about 300 tons, and rest on solid cubes of concrete, each of which weighs over 250 tons. The upper ends of these struts have been taken down plate by plate, by cutting out the rivets, but the lower portions of them are being sent down in 40-foot lengths.

From start to finish the whole structure has been demolished within a period of less than six months, which, considering that every rivet and stay from 3¼ inches in diameter downward had to be sawn through, as every nut was completely set with rust, reflects the highest credit on all concerned, and in particular on Mr. W. T. Andrews, who devised in detail the whole plan of operations.

A HISTORY OF THE WRIGHT FLYING EXPERIMENTS.

By Octave Chanute.

Having made some experiments of my own in gliding flight in 1896 and published a full description of them, with photographs and detailed plans, in the Aeronautical Annual of 1897, inviting other searchers to improve upon my practice, I was written to on May 13, 1900, by Mr. Wilbur Wright, who stated that he was minded to experiment, had some ideas of his own, although he believed no financial profit would follow, and who asked for information and suggestions.

These were gladly furnished, and he and his brother Orville spent some weeks in the summer of 1900 at Kitty Hawk, N. C., testing the value of their modifications of what I had termed the "double decked" machine of 1896.

At the close of the season they advised me fully of the results, inasmuch as I was unable to visit them during these experiments, which, although yielding only brief glides, confirmed in their minds the correctness of their original opinions.

These experiments were resumed at Kitty Hawk in July, 1901, and I visited the camp in August. The glides were not much longer or flatter than those of 1896, but the control of the apparatus was much better, and I recognized at once that the Wright brothers had much improved upon my own construction and practice.

At my request Mr. Wilbur Wright read a paper before the Western Society of Engineers of Chicago on September 18, 1901, in which he gave an account of what he and his brother had accomplished.

The brothers again experimented in 1902, and I paid them a visit. They gave an account of the further progress which they had made in a paper read before the Western Society of Engineers June 24, 1903. The main results described were that the glides, all performed dead against the wind, were getting flatter and flatter, with corresponding increase of length, and that the apparatus was getting to be under almost perfect control.

Up to that time I had deprecated the addition of a motor or of a propeller, as tending to produce complications, before control and skill had been acquired, or the science of the birds had been mastered, but it then became evident that a true flying machine might be attempted, and the Wright brothers themselves began to think that they might secure some pecuniary reward for labors which up to that time had been carried on purely in the interest of science.

They built, therefore, in 1903 a power flying machine equipped with a motor and propeller, all constructed by their own hands after many laboratory experiments.

I visited their camp at Kitty Hawk in November, 1903, this being the time set for testing the apparatus, but I only remained one week, the breaking in the meantime of individual parts, such as axles, propeller hubs, connections, etc., producing delays for repairs and finally a trip to Dayton (800 miles away), where the machine had been built, in order that the repairs should be made in accordance with the patterns.

At last, on December 17, the Wright brothers made their first flights with their power machine. They made three straightaway flights against an icy, gusty wind of twenty miles an hour, the longest being 852 feet over the ground and occupying fifty-nine seconds. The operations were then suspended until the ensuing spring, and I was advised of the results.

The field of operations was then transferred to Dayton, in order to be near their machine shop, and the whole of the 1904 season was spent in learning how to sweep a circle in the air when a wind was blowing. There were, of course, a number of miscarriages and breakages which required changes to be made and parts to be strengthened, but it is a gratifying fact that in all their numerous flights neither of the brothers met with an accident resulting in personal injury.

I witnessed a flight at Dayton on October 15, 1904, of 1,377 feet, performed in twenty-four seconds. The start was made from level ground, and the machine swept over about one-quarter of a circle at a speed of thirty-nine miles an hour. The wind was blowing diagonally to the starting rail and about six miles an hour.

After the machine had progressed some five hundred feet and risen about fifteen feet it began to cant over to the left and assumed an oblique transverse inclination of fifteen to twenty degrees. Had this occurred at an elevation of, say, one hundred feet above the ground Orville Wright, who was on the machine on this occasion, could have recovered an even balance even with the rather imperfect arrangement for control at that time employed. But he felt himself unable to do so at the height then occupied and concluded to come down.

This was done while still turning to the left, so that the machine was going with the wind instead of against it, as practised where possible.

The landing was made at a speed of forty-five to fifty miles an hour, one wing striking the ground in advance of the other, and a breakage occurred which required one week for repairs. The operator was in no wise hurt.

This was flight No. 71 of the 1904 series. On the preceding day the brothers had alternately made three circular flights, one of 4,001 feet, one of 4,902 feet, and one of 4,936 feet, the latter covering rather more than a full circle.

Still another machine was built for the 1905 experiments, embodying the improvements suggested by the practice of the two preceding years. At last the control was perfected, against the wind, across the wind and down the wind. This occupied all the summer, and it was September and October before the long flights covering eleven to twenty-four miles could be made.

These I did not see, being at that time in Massachusetts, but on my visit to Dayton, in November, I not only saw photographs of these flights, but gathered abundant confirmation from eye-witnesses; so that I thoroughly believe all that the Wright brothers have stated to the public about their own performances.—New York Herald.

PHOTOGRAPHIC NOTES.

A New Lens for Telephotography.—A firm in Geneva some time since placed upon the market a camera called the "telephot." This has a lens of very long focus, and two mirrors so arranged that the length of the camera is reduced to about one-third of what would otherwise be necessary. The most improved model takes pictures 18 x 24 centimeters, uses a lens of 3 meters (practically 10 feet) in focal length, and works at the large aperture of f/10. The well-known firm of Zeiss has now perceived the importance of this innovation and has introduced a tele-objective which can be used on hand cameras, and does away with the fragile mirrors. At present this lens is made in two sizes; the smaller is intended for hand cameras 9 x 14 centimeters, has a focal length of 45 centimeters, threefold enlargement, and aperture f/14; the larger is intended especially for balloon photography, and as the rapid vibrations and twistings of the balloon demand a very short exposure, has a focal length of 80 centimeters and a working aperture of f/10. To insure stability, this is mounted in a specially-made metal camera with a focal plane shutter. This is the most extraordinary camera in appearance yet devised, being a long box, the entire front of which is taken up by the lens, like a giant eye. When the lens is drawn out for use, the thing looks like an ancient blunderbuss. A small field of view renders any ordinary finder absolutely useless, and the apparatus is fitted with a telescope sight such as is applied to firearms of precision. The instrument is fixed-focus, so the only necessary manipulation is plate changing and setting the shutter. The instrument is therefore admirably adapted for strategic, maritime, and zoological purposes.—Die Photographische Industrie, 1907:62.

Alum in the Combined Toning Bath.—In order to harden the film of gelatine printing-out papers during the toning, alum is often added to the combined toning and fixing bath. This is done when the bath is finished and cold, in order to prevent the decomposition of the hypo which takes place when the alum is added to a hot solution. The result, however, is the precipitation of most of the aluminium and hydroxide, so that only small quantities of alum remain in solution, and the hardening of the film is not sufficiently accomplished. Lumières and Seyewetz have discovered that sodium bisulphite possesses the property of hindering the decomposition of hypo by alum, and have recently applied this to the combined bath. They give the following formula:

Water	1,000 c. cm.
Hypo	250 g.
Commercial liquid sodium bisulphite	10 c. cm.
Lead acetate	2 g.
Potash alum	40 g.
Chloride of gold (1 per cent solution)	60 c. cm.

This bath is rather slow in its toning action, but it hardens the prints to such an extent that they will stand without melting temperatures up to nearly 175 deg. F., while pictures in an ordinary toning bath begin to melt in the neighborhood of 95 deg. This bath is therefore especially useful for summer and tropical work.

Determination of Focal Length.—Lindsay Johnson gives (Photography, 1906:430) a new method for this measurement. It is necessary to select two objects on the horizon far enough away from the camera to be considered at infinity and subtending an angle of exactly 45 deg., for instance, two lightning rods, spires, or other well-defined objects. Focus sharply; then the distance of the images on the ground glass is the exact focal length. If the angle between the objects is 26 deg. 34 min., the focal length is twice their separation; if it is 18 deg. 26 min., three times the separation.

A Purely Physical Printing Process.—A printing process, in which no chemical action is involved, is described by F. Alefeld in the Chemiker Zeitung. It depends on the phenomenon of heliotropic crystallization, which was described as early as 1728. Certain materials in certain solutions show a tendency to travel from the weakly lighted to the strongly lighted parts. As especially sensitive in this direction, according to Alefeld, have been proved to be the resinates and thioresinates of most of the metals. These have long been used for china decoration, are easily soluble in ethereal oils, and after firing leave a strongly-colored ash which consists principally of metallic oxides. Solutions of such resinates in ethereal oils are coated on glass or porcelain plates and dried for fifteen minutes at 212 deg. F. They are then exposed under a negative in direct sunlight. The image begins to be visible in about four minutes, and is complete in thirty. It is then fired in the usual manner. The outlines of the prints are perfectly sharp, while previous processes have given very indistinct outlines. The experimenter has not yet succeeded in getting perfectly clean whites, but the process is nevertheless of obvious importance for ceramic decoration.

ELECTRIC HAULAGE ON CANALS.

EXPERIMENTS ON EUROPEAN SYSTEMS AND THE PRACTICAL RESULTS.

Consul Walter C. Hamm, of Hull, sends the following informatory paper on the application of electric power to canal haulage. The paper was prepared by Prof. E. W. Marchant, of the chair of electrotechnics in the University of Liverpool, for the London Chamber of Commerce, and was presented to the Royal Commission now investigating the subject of haulage on the canals and inland waterways in England:

Electrical power has not hitherto been extensively used for towing barges along canals for several obvious reasons. In the first place, the application of electrical power for haulage involves a considerable capital outlay, and with the great difficulty met with in raising fresh capital for canal purposes the absence of any scheme of this kind in England is not surprising. Secondly, a really satisfactory system of electrical haulage has only been demonstrated on a practical scale within the past few years, and it is not remarkable that while this matter was in its experimental stage no rapid development took place. There have been one or two cases in which towing by electric power has been adopted on unsuitable canals and has had to be abandoned; the failure of such schemes has been in every case almost entirely due to the fact that the traffic along the canal was not of sufficiently large volume.

In order that a system of electrical haulage may be financially successful a good and regular traffic is necessary. It is difficult to say definitely when an electrical haulage scheme becomes economically desirable on a canal, as the results obtained must depend very largely on local conditions; but on the Teltow Canal in Germany the conclusion arrived at was that the adoption of electrical haulage, on purely economical grounds (that is, taking into account only total cost of haulage, including interest and depreciation on the haulage plant) saved money when the traffic exceeded 2,000,000 tons per annum. This result applies of course solely to this canal, which is the most elaborately equipped of its kind in the world, the total cost (including generating stations), with a tractor track laid on both banks, being about £6,000 ($29,199) per mile. With a smaller capital expenditure a saving would result, of course, when the traffic was considerably less than 2,000,000 tons.

The methods of haulage by tractors that have been used may be divided into three groups: First, tractors running on an ordinary towpath; second, tractors running on a light railway track laid on the towpath; third, tractors on an overground rail by the side of the canal.

TRACTORS RUNNING ON ORDINARY TOWPATH.

The first type has been used at Brussels, on the Charleroi Canal, and at Douai, on the Canal d'Aire et de la Deule. The advantage over the other two lies entirely in the small cost of equipping the canal for this type of traction. The tractor used on both these

canals weighs between two and three tons and carries a motor of 10 horse-power. It has flat-rimmed cast-iron wheels; at Douai these wheel rims were of the corrugated form ordinarily employed in this country for road traction engines. Current is collected from overhead wires; where continuous current (Douai) is employed only two trolleys are required, while with three-phase current (Charleroi) three become necessary. The tractor carried a seat for the driver and a controller for the motor. The cost of equipping the track with the necessary trolley wires amounts to about £300 ($1,460) per mile, using wooden poles. In spite of this the system is a very uneconomical one. The efficiency of the tractors is only 40 per cent, while the wear and tear on the machinery is very heavy. A table given by M. La Riviere in his report on mechanical traction on rivers, canals, and lakes, read at the International Congress at Milan, is interesting in this respect.

The average life of the principal pieces of the tractors used on the Canal d'Aire et de la Deule was as follows: Endless screw (bronze), 3½ months; steel gear wheel, 2½ years; thrust block, 1 year; rear pillow block of endless screw, 2½ years; carter pillow blocks, 6 months; pillow block for axle arm, 2 years; forward motor pillow block, 2½ years; rear pillow block, 2½ years; driving wheel, 2 years.

It will be seen, therefore, that the majority of the wearing parts require replacement in just over two years. The main drawback, however, to this system is the heavy cost of maintaining the towing path in proper condition. While horse traction requires only a light cinder or gravel track, electric traction with 2½-ton tractors requires a good macadamized road, and it was found at Douai that the average cost of upkeep was increased from 234 francs per kilometer ($45.16 per 0.6214 mile) when horses were used on the track, to 875 francs ($168.87) with electric tractors. The wear on the towpath due to the running of these heavy tractors on the canal banks is particularly noticeable at Douai on that part of the canal not yet equipped with rail traction. The driver in some parts has great difficulty in maintaining his place in the tractor, even at the low speed of 2 miles an hour at which it is running. It is now generally agreed that this system of haulage is one that is much more costly (in spite of the small capital outlay) than haulage by means of tractors running on rails.

TRACTORS RUNNING ON A LIGHT RAILWAY TRACK.

The two most important installations in which electrically-driven tractors running on a light railway track are used for towing canal barges are at Douai, on the Canal d'Aire et de la Deule, and on the Teltow Canal south of Berlin. The Teltow Canal is a municipal enterprise and has been constructed under the general direction of Herr von Stubenrach, the *Landrat* of the province of Teltow. Already several large factories have been built on its banks, and although the canal is only just finished, the price of land on its banks has appreciated to five times its agricultural value.

The electric installation at Douai with rail tractors has been in operation for over a year and affords a very interesting comparison with the electrical system on the same canal, in which tractors running on the banks are used, which has been in operation since 1897. The overhead trolley wire is of the usual type used on tramways, with the exception that it is supported from below, as the trolley collector runs on top of the wire, instead of pressing against the lower side of it. The return path for the current is through the rails, which are bonded as in the ordinary tramway. The track is of rails weighing 40 pounds per yard, laid on wooden sleepers and ballasted with cinders and broken stone, and the cost of laying is about 17,000 francs per kilometer ($5,353 per mile). The cost of upkeep of this track is estimated at under 400 francs per kilometer ($121.17 per mile). The locomotives running on this weigh 8 tons and are capable of exerting a pull of 1.3 tons with the rails in their normal condition. Efforts as great as 1.6 tons have been obtained when the rails were exceptionally dry and clean. This effort is sufficient to tow four boats carrying 290 tons each, at 2 miles per hour. The tractor is equipped with two 20-horse-power traction motors, operated by a series of parallel controller of the ordinary type used on tram cars. The track is laid on one side of the canal only, so that locomotives going in both directions travel on it. When two barges meet they exchange locomotives and proceed on their way. This arrangement has the advantage of keeping a locomotive driver more or less on a fixed beat. At Teltow both banks are equipped with tractors, so that no difficulty about passing occurs. The canal in this case is divided into sections, on two of which electric locomotives are used. A number of locomotives are maintained on each section—that is, they travel along the section, cross over by a bridge, and return along the other bank of the canal. It is intended when the canal is in full operation to maintain, as far as possible, a fixed time schedule for the barges, so as to avoid delay at the ends of the sections.

The weight of the locomotives in use on each of the canals referred to is about 8 tons, and they are equipped with motors of 8 horse-power (Teltow) and 20 horse-power (nominal) at Douai. The Teltow tractors are designed to tow two barges, each loaded with 600 tons, at a speed of 2.5 miles per hour, and besides being fitted with driving motors have several special electrically-operated appliances so arranged as to enable the locomotive to be completely controlled by one man.

EXPENSE AND SPEED.

The tractors at Douai are much simpler, and are a great deal cheaper, although the two motors are of 20 horse-power. The amount paid for a locomotive is 8,000 francs ($1,544), and the cost of upkeep is estimated at about $90 per annum. The tractive effort required to haul barges depends on a great number of conditions, the most important of which are the speed and the ratio of barge section to canal section. At Teltow, with a ratio of 1.5 and at a speed of 2.5 miles per hour, the tractive resistance is very nearly 2 pounds per ton with a 600-ton barge. The energy consumed is 5.6 watt hours per ton-mile, costing 0.0112 cent per ton-mile, and the efficiency of the locomotive is 67 per cent. At Douai, on the Scarpe detour of the Canal d'Aire et de la Deule, the ratio of barge section to canal section is 1:5.22. On the main canal it is only 1:3.89; at a speed of 2 miles per hour the tractive resistance is 2.5 pounds per ton, with 2 by 300-ton barges. The energy consumed per ton-mile is 7.2 watt hours, costing 0.0144 cent per ton-mile, and the efficiency of the locomotive 68 per cent. It is significant that no greater speed than 2¼ miles an hour is allowed on the German canals, while on the French canals a limit of 2 miles an hour is given. The objections to a higher speed are the increase in the silting up of the canal, the greater wear on the banks, and the greatly increased tractive effort required. All experience shows the inadvisability of increasing the speed of towing on canals to any very great extent, whatever method of haulage is employed.

The total cost of electrical haulage on the Teltow Canal for different traffics is as follows: At a total traffic of 2,000,000 tons, 1.72 cents per ton-mile; traffic of 3,000,000 tons, 1.48 cents per ton-mile; traffic of 4,000,000 tons, 1.2 cents per ton-mile. At Douai the gross receipts per ton-mile (net load) were 1.32 cents, and the expenses 0.94 cent. Of the expenses 0.0352 cent represents the cost of energy used for barges, and the remainder the upkeep charge on the plant, labor charges, etc. The traffic on this canal has increased from 1,000,000 tons in 1900 to over 3,500,000 tons last year.

OTHER EXPERIMENTS—ADVANTAGES OF ELECTRICITY.

Among other methods that have been adopted is the Bouquie system of chain haulage used in the Pouilly tunnel in Burgundy, in which the haulage is effected by a drum on the hauling tug driven by an electric motor. In this case the power required for the electrical haulage is obtained by means of water turbines driven by the waste water at a lock near one end of the canal.

Electric tugs with screws have also been used. The objection to tugs is the churning action of the screws which stirs up the mud in the canal bed, and to a certain extent damages the banks. This later effect is, however, not serious. The electric tug has only half or less than half the efficiency of the electric locomotive.

One of the great advantages which the use of electrical energy possesses over all other methods of mechanical towing is the fact that it gives a supply of power available within limits at any point on the canal banks. Some of the uses to which electrical energy has been put on the canals where electric haulage has been adopted, are as follows: Electric capstans are used at the lock; electric cranes at loading places; electrically-driven winches are used at a harbor designed for ship repairs by which any boat up to 150 feet long can be hauled out of the water on carriers, thus obviating the necessity for a drydock; an electrically-driven pump is fitted at the lock to pump back water into the upper reach (Havel), in case the loss by lockage is too great, and electric lights are placed at the lock to enable it to be used at night; electric power has been used for lighting a canal, and for operating locks and swing bridges, the saving in labor effected by its use being estimated at 50 per cent.

Electrical haulage has only proved successful on canals on which there is a good volume of traffic. In all successful installations electric locomotives running on the towpath have been employed in preference to tugs. The economy in general upkeep of the canal in getting rid of the wash from the screws is sufficient in some cases to compensate for the interest and depreciation charges on the electrical equipment. The total cost of electrical haulage per ton-mile at Douai is 0.094 cent, with a traffic of 3,500,000 tons per annum.

A HYDRAULIC ANALOGY OF RADIATION.

MUCH has been written of late concerning the radiation of energy, but particularly respecting the forms which we recognize as light and heat. The scientific world is always deeply interested in this branch of physics, and just now the industrial world has been giving the subject considerable attention, primarily because of the endeavor to produce more efficient lamps, both gas and electric. Information respecting the form of these lamps and the reason why they are better than the older types is looked for eagerly. For a time new forms of lamps, particularly electric lamps, were put forward with sufficient frequency to keep the interest keyed up to a high point, and more recently those who are able to write upon the scientific phases of the problem of improving lamp efficiency have been giving the public the benefit of their knowledge.

Much has been said about selective radiation, an effect to which is attributed part, at least, of the better efficiency of the newer forms of lamp. But although certain of these lamps undoubtedly show selective radiation, it seems evident that their improvement depends more upon an increase in temperature. As the quantity of light radiated increases with the twelfth power of the temperature, but a slight increase in temperature is necessary to increase very considerably the amount of light; in fact, with an incandescent filament at about 2,000 deg. an increase in temperature of 100 deg. C. will about double the amount of light delivered. Selective radiation, while it does take place, cannot, therefore, be credited with much of the improvement, since it is known that the newer filaments are operated at a higher temperature than the old.

Nevertheless, the subject of selective radiation is of great interest, not only theoretically, but from a practical viewpoint, because it is only in this direction that we can hope to obtain efficiencies which would be respectable as compared with those of other transforming devices. Selective radiation is defined somewhat indefinitely as a radiation which does not follow the law of radiation followed by that hypothetical radiator, a black body. In other words, it generally refers to a form of radiation, the luminous rays of which bear a larger proportion to the whole than do those of the black body. The more selective the radiation, or, rather, the smaller the proportion of the heat waves, the better the efficiency. Just what the mechanism is which produces this result is not known, though it must, of course, depend upon the molecular structure of the radiating body. The subject is a little hard to understand at first, and therefore any suggestions tending to make it more comprehensible are welcome. A suggestion of this kind is made by Dr. R. W. Wood, in Nature, April 11. He suggests a hydraulic analogy of the radiating body which serves to illustrate the radiation in general, and can be made to show how selective radiation would take place. Analogies must always be used with reserve, and no one who is not very familiar with all the phenomena exhibited during the action illustrated should attempt to make them or extend them further when suggested by others. But when used within the proper limits, they are a useful and instructive aid to the imagination.

Dr. Wood's analogy is a simple one, and while it does not show why radiation should be selective, it does show how it can be so. A radiating body is likened to a hollow vessel into which water is poured. This vessel is provided with openings at the bottom, through which the water issues. These openings may be of different sizes, thus corresponding to different wavelengths of radiation. When water is poured into the vessel it will flow out from the openings at the bottom at a rate depending upon the height of water in the vessel; and if the rate of inflow be constant, the level of water in the vessel will finally reach a fixed point. This depth of water corresponds to the temperature of a radiating body, the liquid poured into it to the heat absorbed, and the water issuing from the lower openings to the radiations given out. Under fixed conditions the outflow is equal to the inflow. The larger openings correspond to the longer wavelengths, and the smaller ones to the shorter. More water will, therefore, issue from the larger openings, and this corresponds to the greater radiation of energy from a hot body in the form of heat waves. Increasing the rate of inflow raises the height of water—that is to say, the temperature of the body—until this has reached such a point that the outpour again equals the inflow; but the larger wave-lengths—that is to say, the larger jets—will still represent the greater portion of the radiation.

Selective radiation may be represented by plugging up more or less tightly those openings which correspond to the rays which are given off in diminished quantity. The outflow from these openings will thus be diminished. The immediate result will be to decrease the rate of outpour of the entire vessel; therefore, the height of water—that is to say, the temperature—will increase until conditions again become stable. But now, although we may have the same outflow of energy or water, we have a higher temperature and a greater proportion of outflow in the smaller jets, corresponding to the shorter wave-lengths. Further, a good radiator must be a good absorber, and a selective radiator must also be a selective absorber. This may be illustrated by plunging our vessel, while empty, in a vessel of water and allowing the latter to flow into it through the openings at the bottom. If the larger openings are still plugged up, a greater absorption will take place through the smaller openings. This corresponds to the reflection of the longer wave-lengths.

The analogy is very pretty, since it shows clearly how a radiating body behaves. As mentioned above, it does not attempt to show why it behaves in this way. This effect may be due to several reasons. Selective radiation may take place on account of the molecular structure, or it may be due to a surface formation. The body, although made up of a material usually a good reflector, may be given such a form as to force it to absorb practically all the light which falls upon it. For example, a bundle of polished steel needles will absorb all of the beam of light falling upon their points, although the metal of each needle is a good reflector. The action is due to successive reflection from surface to surface until the radiation is entirely taken in. Such a body should act in the reverse sense, and thus become a good radiator.

Among other things, Dr. Wood mentions an interesting point. Transparent bodies are naturally poor radiators, yet these can be made to radiate. He found

that beads of fused sodium pyrophosphate did not radiate at all, and if they are allowed to become cold, they become traversed by many cleavage planes and lose their transparency. Then, if re-heated, they radiate strongly until they again become fused. Air-bubbles inclosed within a transparent body also cause it to radiate. This effect has not been explained, but it is thought that it depends in some way upon a surface action.—Electrical Review.

[Continued from Supplement No. 1638, page 26246.]

AERIAL LOCOMOTION.

WITH A FEW NOTES OF PROGRESS IN THE CONSTRUCTION OF AN AERODROME.*

By Alexander Graham Bell.

A MACHINE THAT WILL SUPPORT ITSELF AT LOW VELOCITY DESIRABLE.

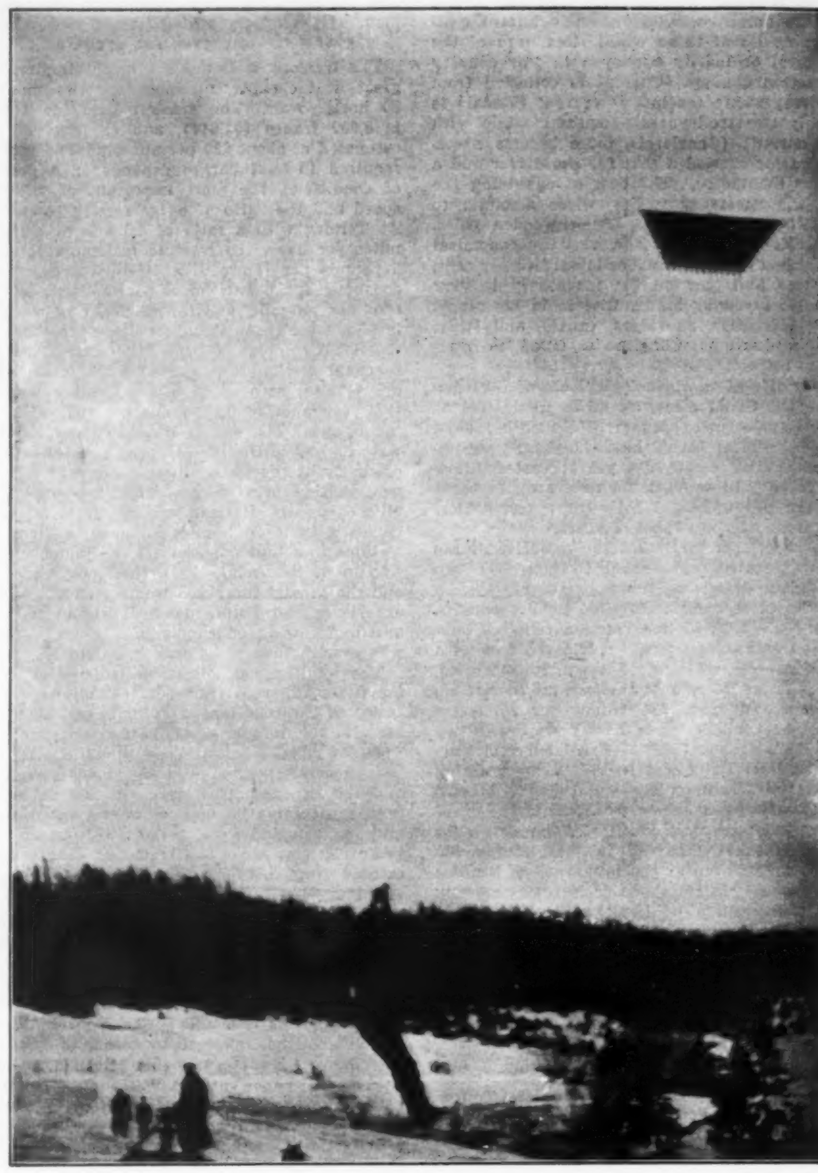
The Wright brothers' successful flying-machine travels at the rate of about thirty-seven miles an hour; and, judging from its great flying weight (nearly two pounds per square foot of supporting surface), it is unlikely that it could be maintained in the air if it had a very much less velocity. But should an accident happen to a body propelled through the air with the velocity of a railroad train, how about the safety of the occupants? Accidents will happen, sooner or later, and the chances are largely in favor of the first accident being the last experiment. While, therefore, we may look forward with confidence to the ultimate possession of flying-machines exceeding in speed the fastest railroad trains, it might be the part of wisdom to begin our first experiments at gaining experience in the air with machines traveling at such moderate velocities as to reduce the chances of a fatal catastrophe to a minimum. This means that they should be light-flying machines—that is, the ratio of weight to supporting surface should be small.

While theory indicates that the greater the weight in proportion to supporting surface consistent with flight, the more independent of the wind will the machine be, yet it might be advisable to begin, if possible, with such a moderate flying weight as to permit of the machine being flown as a kite. There would be little difficulty, then, in raising it into the air, and should an accident happen to the propelling machinery, the apparatus would descend gently to the ground; or the aviator could cast anchor, and his machine would continue flying, as a kite, if the wind should prove sufficient for its support. If it could fly, as a kite, in a ten-mile breeze, then a velocity of only ten miles an hour would be sufficient for its support as a flying machine in calm air, while a less speed would suffice in heading into a moderate wind.

Such velocities would be consistent with safety in experiments, especially if the flights should be made over water instead of land, and at moderate elevations above the surface. Under such circumstances the inevitable accidents which are sure to happen during first experiments are hardly likely to be followed by more serious consequences than a ducking to the man and the immersion of the machine. If the man is able to swim and the machine to float upon water, little damage need be anticipated to either.

There are two critical points in every aerial flight—its beginning and its end. A flying-machine adapted to float upon water not only seems to afford a safe means of landing, but also promises a solution of that most difficult of problems—a safe method of launching the apparatus into the air. If the supporting floats are so formed as to permit of the machine being propelled over the surface of the water like a motor boat, then, if sufficient headway can be gained under the action of her aerial propellers, the machine can be steered upward into the air, rising from the water, after the manner of a water bird, in the face of the wind. This seems to be the safest method of gaining access to the air; but, of course, its practicability depends upon possibilities of lightness and speed yet to be demonstrated.

In any event, if the machine, man and all, is light enough to be flown as a kite, it can be towed out of the water into the air through the agency of a motor boat; and, upon land, it would not even be necessary for it to gain headway before rising, for in a supporting wind it would rise of itself into the air, if relieved of the weight of the man, and fly as a kite. It would then be a comparatively simple matter to lower the kite to a convenient height from the ground, and to hold it steadily in position by subsidiary lines while the aviator ascends a rope ladder to his seat in the machine. In this way the man would not be exposed to danger during the critical operation of launching the appar-

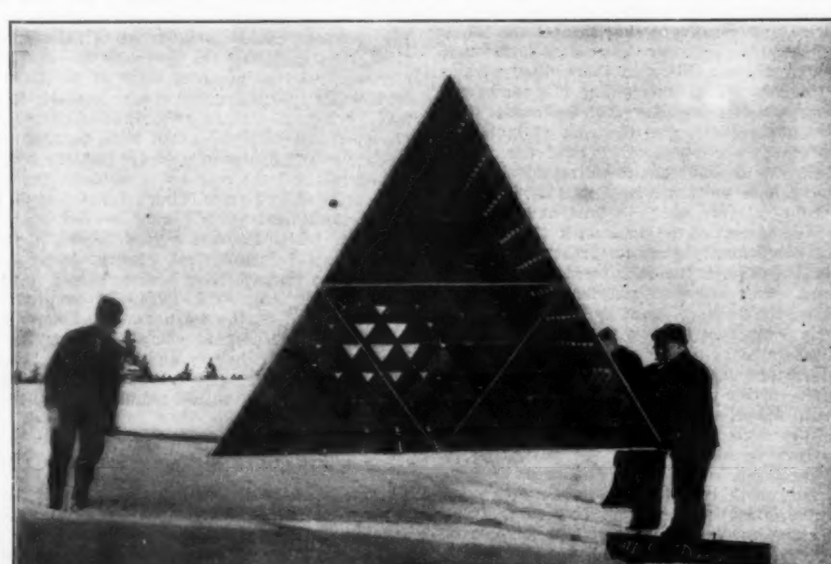


THE "FROST KING" FLYING IN A TEN-MILE BREEZE, AND SUPPORTING A MAN ON THE FLYING ROPE.

During the experiment the rope straightened under the pull of the kite, and the man was raised to a height of 30 or 40 feet. He was in great peril, but fortunately was brought down safely. Photograph by Alexander Graham Bell. Published in the National Geographic Magazine.

64-CELLED TETRAHEDRAL KITE FLYING FROM FLAG-POLE.

Photograph by D. G. McCurdy. Published in the National Geographic Magazine.



SIDE VIEW OF THE "FROST KING," SHOWING HOW CLOSELY THE CELLS ARE MASSED TOGETHER.

Photographed by E. H. Cunningham. Published in the National Geographic Magazine.

TETRAHEDRAL KITES IN FLIGHT, ONE OF THEM LIFTING A MAN.

* An address read before the Washington Academy of Sciences, December 13, 1906, and specially revised by Dr. Bell for publication in the National Geographic Magazine.

atus into the air, and by a converse process a safe landing could be effected without bringing the machine to the ground. The chance of injury to the machine itself would also be much lessened by relieving it of the weight of the man during the initial process of launching and the final process of bringing the machine down to the ground.

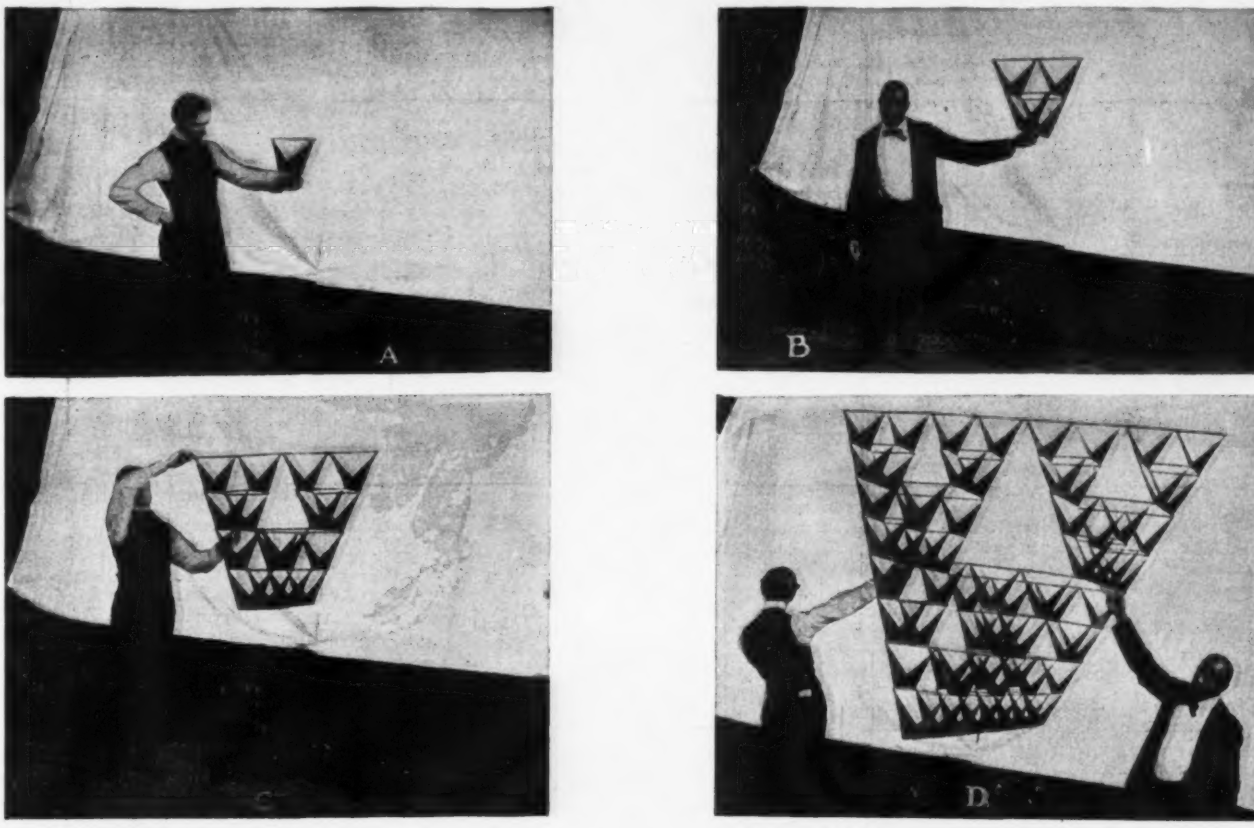
Such speculations as these of course are only justifiable upon the assumption that it is possible to construct an aerial vehicle large enough and strong enough to support a man and an engine in the air, and yet light enough to be flown as a kite in a moderate breeze with the man and engine and all on board. My experiments in Nova Scotia have demonstrated that this can be done; and I now therefore find myself seriously engaged in the attempt to reduce these ideas to practice by the actual construction of an aerodrome of the kite variety. The progress of experiment may be divided into three well-marked stages: the kite stage, the motor-boat stage, and the free flying-machine rising from the water.

THE KITE STAGE.

In April, 1899, I made my first communication on the subject of kites to the National Academy of Sciences in a paper entitled "Kites with Radial Wings," which was reviewed, with illustrations, in the Monthly Weather Review for April, 1899 (vol. xxvi, pp. 154-155, plate xi). I made another communication to the National Academy on the 23d of April, 1903, upon "The Tetrahedral Principle in Kite Structure," which was published with ninety-one illustrations and an appendix in the National Geographic Magazine for June, 1903 (vol. xiv, pp. 220-251). The substance of the present address was presented in part to the National Academy of Sciences at their recent meeting in Boston, Massachusetts, November 21, 1906. The experiments referred to, which were undertaken at first for my own pleasure and amusement, have gradually assumed a serious character, from their bearing upon the flying-machine problem.

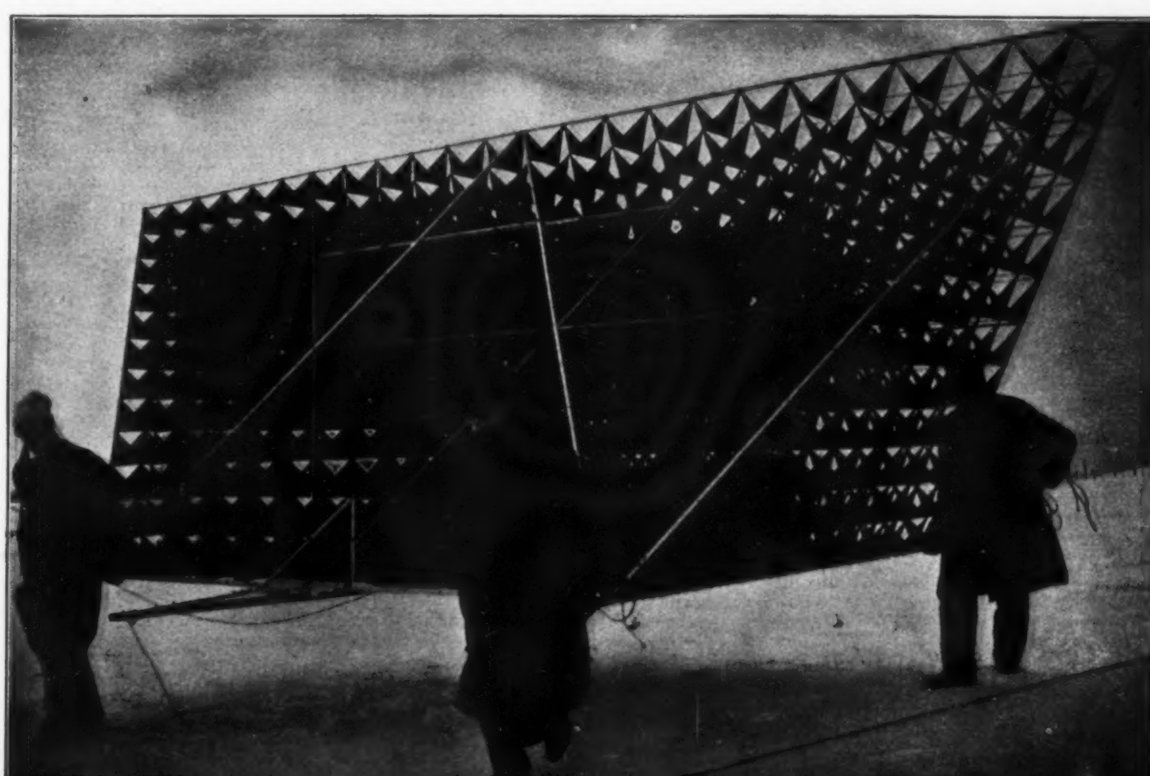
The word "kite" unfortunately is suggestive to most minds of a toy—just as the telephone at first was thought to be a toy; so that the word does not at all adequately express the nature of the enormous flying structures employed in some of my experiments. These structures were really aerial vehicles rather than kites, for they were capable of lifting men and heavy weights into the air. They were flown after the manner of kites, but their flying cords were stout manila ropes. They could not be held by hand in a heavy breeze, but had to be anchored to the ground by several turns of the ropes around stout cleats, like those employed on steamships and men-of-war.

One of the great difficulties in making a large



A. SINGLE-WINGED CELL. B. FOUR-CELLED KITE. C. SIXTEEN-CELLED KITE. D. SIXTY-FOUR-CELLED KITE.

On this, the hollow plan of construction, an empty space appears in the middle of each kite—B, C, or D—equivalent in volume to one-half of the cubical contents of the whole structure. From the National Geographic Magazine.



CARRYING THE "FROST KING" TO THE TESTING GROUND.

This kite was composed of 1,300 light winged cells closely massed together. Photograph by E. H. Cunningham. Published in the National Geographic Magazine.

SOME OF DR. BELL'S TETRAHEDRAL CELLS SEEN SEPARATELY AND COMBINED INTO KITES OF DIFFERENT SIZES.

structure light enough to be flown as a kite has been pointed out by Prof. Simon Newcomb in an article in McClure's Magazine, published in September, 1901, entitled "Is the Air Ship Coming?" and this difficulty had so much weight with him at that time as to lead him to the general conclusion that—

"The construction of an aerial vehicle which could carry even a single man from place to place at pleasure requires the discovery of some new metal or some new force."

This conclusion the Wright brothers, and now Santos Dumont, have demonstrated to be incorrect; but Prof. Newcomb's objections undoubtedly have great force, and reveal the cause of failures of attempts to construct large-sized flying-machines upon the basis of smaller models that actually flew. Prof. Newcomb shows that where two aerial vehicles are made exactly alike, only differing in the scale of their dimensions, the ratio of weight to supporting surface is greater in the larger one than in the smaller, the weight increasing as the cube of the dimensions, whereas the supporting surfaces only increase as the squares. From this the conclusion is obvious that if we make our structure large enough it will be too heavy to fly—even by itself—far less be the means of supporting an additional load like a man and an engine for motive power. This conclusion is undoubtedly correct in the case of structures that are "exactly alike excepting in their dimensions," but it is not true as a general proposition.

EVADING AN OLD LAW.

A small bird could not sustain a heavy load in the air; and while it is true that a similar bird of double the dimensions would be able to carry a less proportionate weight, because it is itself heavier in proportion to its wing surface than the smaller bird—eight times as heavy in fact, with only four times the wing surface—still it is conceivable that a flock of small birds could sustain a heavy load divided equally among them; and it is obvious that in this case the ratio of weight to wing surface would be the same for the whole flock as for the individual bird. If, then, we build our large structure by combining together a number of small structures each light enough to fly, instead of simply copying the small structure upon a larger scale, we arrive at a compound or cellular structure in which the ratio of weight to supporting surface is the same as that of the individual units of which it is composed, thus overcoming entirely the really valid objections of Prof. Newcomb to the construction of large flying-machines.

In my paper upon the tetrahedral principle in kite structure I have shown that a framework having the form of a tetrahedron possesses in a remarkable degree the properties of strength and lightness. This is specially the case when we adopt as our unit structure the form of the regular tetrahedron, in which the skeleton frame is composed of six rods of equal length, as this form seems to give the maximum of strength with the minimum of material. When these tetrahedral frames or cells are connected together by their corners they compose a structure of remarkable rigidity, even when made of light and fragile material, the whole structure possessing the same properties of strength and lightness inherent in the individual cells themselves.

The unit tetrahedral cell yields the skeleton form of a solid, and it is bounded by four equal triangular faces. By covering two adjoining faces with silk, or other material suitable for use in kites, we arrive at the unit "winged cell" of the compound kite, the two triangular surfaces in their flying position resembling a pair of wings raised with their points upward, the surfaces forming a dihedral angle (Fig. A).

Four of these unit cells, connected together at their corners, form a four-celled structure having itself the form of a tetrahedron containing in the middle an empty space of octahedral form equal in volume to the four tetrahedral cells themselves (Fig. B).

In my paper I showed that four of these four-celled structures connected at their corners resulted in a sixteen-celled structure of tetrahedral form containing, in addition to the octahedral spaces between the unit cells, a large central space equivalent in volume to four of the four-celled structures (Fig. C).

In a similar manner four of the sixteen-celled structures connected together at their corners form a sixty-four-celled structure (Fig. D).

Four of the sixty-four-celled structures form a two hundred and fifty-six-celled structure, etc., and in each of these cases an empty space exists in the center equivalent to half of the cubical contents of the whole structure, in addition to spaces between the individual cells and minor groups of cells.

Kites so formed exhibit remarkable stability in the air under varying conditions of wind, and I stated in my paper that the kites which had the largest central spaces seemed to be the most stable in the air. Of course, these were the structures that were composed of the largest number of unit cells, and I now have reason to believe that the automatic stability of these kites depends more upon the number of unit cells than upon the presence of large empty spaces in the kites; for I have found, upon filling in these empty spaces with unit cells, that the flying qualities of a large kite have been greatly improved. The structure, so modified, seems to fly in as light a breeze as before, but with greatly increased lifting power, while the gain in structural strength is enormous.

I had hitherto supposed that if cells were placed directly behind one another without providing large spaces between them comparable to the space between the two cells of a Hargrave box kite, the front cells would shield the others from the action of the wind, and thus cause them to lose their efficiency; but no very marked effect of this kind has been observed in practice. Whatever theoretical interferences there may be, the detrimental effects upon the flying qualities of a kite are not, practically, obvious, while the gain in structural strength and in lifting power outweighs any disadvantages that may exist. I presume that there must be some limit to the number of cells that can be placed in close proximity to one another without detrimental effect, but so far my experiments have not revealed it.

EXPERIMENTS WITH "THE FROST KING."

To test the matter, I put together into one structure all the available winged cells I had in the laboratory—1,300 in number. These were closely attached together, without any other empty spaces in the structure than those existing between the individual cells themselves when in contact at their corners.

The resulting kite, known as "The Frost King," consisted of successive layers or strata of cells closely superposed upon one another. The lowest layer, or floor of the structure, consisted of 12 rows of 13 cells each. The cells forming each row were placed side by side, attached to one another by their upper corners, and the 12 rows were placed one behind the other, the rear corners of one row being attached to the front corners of the row immediately behind. The next stratum above the floor had 11 rows of 14 cells; the next 10 rows of 15 cells, etc., each successive layer increasing the lateral dimensions and diminishing in the fore-and-aft direction; so that the top layer, or roof, consisted of a single row of 24 cells placed side by side. One would imagine that a closely-packed mass of cells of this kind, 1,300 in number, would have developed some difficulty in flying in a moderate breeze if the cells interfered with one another to any material extent; but this kite not only flew well in a breeze estimated at not more than about ten miles an hour because it did not raise white caps, but carried up a rope ladder, several dangling ropes 10 and 12 meters long, and more than 200 meters of Manila rope used as flying lines, and, in addition to all this, supported a man in the air.

The whole kite, impedimenta and all, including the man, weighed about 131 kilogrammes (288 pounds), and its greatest length from side to side was 6 meters at the top and 3 meters at the bottom. The sloping sides measured 3 meters, and the length from fore to aft at the square bottom was 3 meters. It is obvious that this kite might be extended laterally at the top to twice its length without forming an immoderately large structure. It would then be 12 meters on the top (39 feet) and 9 meters on the bottom from side to side, without changing the fore-and-aft dimensions or the height. It would then contain more than double the number of cells, and so should be able to sustain in the air more than double the load; so that such a structure would be quite capable of sustaining both a man and an engine of the weight of a man and yet be able to fly as a kite in a breeze no stronger than that which supported the "Frost King."

An engine of the weight of a man could certainly impart to the structure a velocity of 10 miles an hour, the estimated velocity of the supporting wind, and thus convert the kite into a free flying machine. The low speed at which I have been aiming for safety's sake is therefore practicable.

HORIZONTAL AEROPLANES FOUND UNSTABLE.

In the "Frost King" and other kites composed exclusively of tetrahedral winged cells there are no horizontal surfaces (or rather surfaces substantially horizontal, as in ordinary kites), but the framework is admirably adapted for the support of such surfaces. Horizontal aeroplanes have much greater supporting power than similar surfaces obliquely arranged, and I have made many experiments to combine horizontal surfaces with winged cells with greatly improved results, so far as lifting power is concerned. But there is always an element of instability in a horizontal aeroplane, especially if it is of large size, whereas kites composed exclusively of winged cells are wonderfully steady in the air under varying conditions, though deficient in lifting power; and the kites composed of the largest number of winged cells seem to be the most stable in the air.

In the case of an aeroplane of any kind the center of air pressure rarely coincides with the geometrical center of surface, but is usually nearer the front edge than the middle. It is liable to shift its position, at the most unexpected times, on account of some change in the inclination of the surface or the direction of the wind. The change is usually small in steady winds, but in unsteady winds great and sudden changes often occur.

The extreme possible range of fluctuation is of course, from the extreme front of the aeroplane to the rear, or *vice versa*, and the possible amount of change, therefore, depends upon the dimensions of the aeroplane, especially in the fore-and-aft direction. With a large aeroplane the center of pressure may suddenly change to such an extent as to endanger the equilibrium of the whole machine, whereas with smaller aeroplanes, especially those having slight extension in the fore-and-aft direction, the change, though proportionally as great, is small in absolute amount. Where we have a multitude of small surfaces well separated from one another, as in the tetrahedral construction, it is probable that the resultant center of pressure for the whole kite can shift to no greater extent than the centers of pressure of the individual surfaces themselves. It is, therefore, extremely unlikely that the equilibrium of a large kite could be endangered by the shifting of the centers of pressure in small surfaces within the kite. This may be the cause of the automatic stability of large structures built of small tetrahedral cells. If so, one principle of stability would be: *Small surfaces, well separated, and many of them.* The converse proposition would then hold true if we desired to produce instability and a tendency to upset in a squall, namely: *Large surfaces, continuous, and few of them.*

(To be continued.)

THE AIR WE BREATHE.*

By Wilford M. Wilson, Director N. Y. Section, U. S. Weather Bureau.

For nearly eight months in the year the householder in this climate is confronted with the problem of heat, ventilation, catarrh, and coal bills. The other four months he tries to live out of doors in the open air to store up sufficient vitality to carry him through the winter. The condition of the air we breathe within our dwellings and offices during the long period requiring artificial heating is, therefore, worthy of attention.

It is conceded that the free, natural, out-door air is best fitted for the highest physical development in the healthy and in many instances a positive cure for the troubles of the ailing. Sanatoriums are established where the only medicine employed is the tonic of exercise and pure air. Many persons suffering from troubles associated with the air passages live in tents in their own back yards and are cured. Nature's atmosphere may, therefore, be regarded as the true tonic and the nearer the condition of the air within our artificially heated dwellings, offices, and schoolrooms approaches that of the free out-door atmosphere the more health and comfort will be experienced.

Natural dry air is composed of 21 parts by volume of oxygen, 78 parts of nitrogen with one part of argon, helium and xenon and a trace of carbonic acid. These gases are not chemically combined but form a nearly perfect mixture. Although nitrogen is heavier than oxygen and argon is heavier than either nitrogen or oxygen, the law of diffusion of gases operates to maintain so nearly perfect a mixture that samples of air collected from all quarters of the globe from sea level to the highest elevations reached by means of mountains or balloons show essentially the same relative proportions of these various gases. Ammonia, nitrous acid and ozone, dust from the land, salt from the sea, the pollen and spores of plants and innumerable micro-organisms are occasionally met with but the presence of these incidental substances in no way affects the proportion of the chief gaseous elements. Each gas has its own particular office. The nitrogen gives the atmosphere weight and density; carbonic acid gas supports plant life, and oxygen aids combustion. The chemical union of the oxygen of the air drawn in through the lungs with the carbon of the tissues burns up the bodily waste, keeps the body warm and sustains life. The object of all systems of ventilation is therefore to carry off the gases resulting from this process of combustion and to supply air having the full proportion of oxygen. In addition to the principal gases named, which maintain such a remarkably uniform proportion under the most widely varying conditions of temperature and pressure, there is always present in the free air a variable quantity of aqueous vapor or moisture. Dry air is not found in nature nor is it fit to breathe until it has been toned down and softened by the addition of aqueous vapor. Neither plants nor animals will long survive in an atmosphere devoid of moisture and since moisture is an essential part of the natural out-door atmosphere it becomes the question to determine how far the natural proportion of moisture is disturbed by heating the air to the point of comfort. Before taking up the discussion of the effect of artificial heating in its relation to humidity it seems necessary to define as clearly as may be some of the terms to be employed.

The moisture or aqueous vapor in the atmosphere is called its humidity. For further distinction the terms relative and absolute humidity are employed. Absolute humidity is the actual amount of water present in the atmosphere and is usually measured in grains; it may be measured in pints or quarts. An illustration may be of assistance. Take a room 10 feet square and 10 feet high, containing 1,000 cubic feet of perfectly dry air at a temperature of 70 deg. Introduce one half pint of water, by pouring it over a cloth hung in the room. When the cloth is dry it is certain that the half pint of water has passed into the air and this half pint of water now in the form of an invisible vapor in the air is called its absolute humidity. It does not matter how much or how little actual water may be present in the air, a grain or a gallon, whatever the amount may be is its absolute humidity. If a little more than another pint, to be exact, 7,980 grains in all, be poured over the cloth it will all pass into the space in the room as before, but this is the limit of the 1,000 cubic feet of space at a temperature of 70 deg. to absorb moisture and the air is said to be "saturated." Although sanctioned by common usage it is not strictly correct to say that "the air is saturated" for it is a curious fact that exactly the same amount of water will pass into the given space if the air be not present and the room a vacuum, the only difference being that the process of diffusion proceeds a little more rapidly when the air is not present. The absorbing capacity of air, if we may retain that expression, varies with the temperature. At zero 1,000 cubic feet of air will

* Cornell Countryman.

absorb only 40 grains of water while at 70 deg. the capacity increases to 7,980 grains—a little more than one pint.

Relative humidity is expressed in percentage, zero indicating absolute dryness and 100 saturation. If a hygrometer, an instrument for measuring the relative humidity of the air, be placed in the room at the beginning of the experiment the needle or pointer will point to zero on the scale, indicating that the air is perfectly dry. As the first half pint of water is being absorbed the hand will move slowly toward the center of the scale until near the 50 mark, showing that the space is about half filled. The relative humidity is therefore 50 per cent. When the second half pint is absorbed the needle will rest at 100, indicating that the capacity of the space at the given temperature has been satisfied. The relative humidity is, therefore, 100 per cent, and the air in a condition of saturation. If the temperature of the air in the room be lowered from 70 deg. to 20 deg., 6,880 grains—nearly a pint of water—will be condensed, that is squeezed out of the air because air at a temperature of 20 deg. can retain only 0.11 grain per cubic foot. If the action of the hygrometer be noted during the process of cooling it will be seen that the pointer has remained stationary at 100 per cent, showing that although nearly a pint of water has been squeezed out of the air no effect has been produced on the relative humidity. We now have a volume of saturated air at a temperature of 20 deg., which, for the purpose of comparison, may be fairly taken to represent the average condition of the outside atmosphere during the period requiring artificial heating. The temperature of this volume of air will be raised to the point of comfort, 70 deg., and the effect on the relative humidity noted. As the temperature rises the pointer of the hygrometer will move slowly from the 100 mark toward the zero of the scale, passing 75, 50, 40, 30, finally resting at about 25 per cent. There is exactly the same amount of water in the air as when the needle pointed to 100, but the heat has so increased the capacity of the air for moisture that there is only about one-fourth enough to satisfy it. The relative humidity of air has, therefore, been reduced from 100 per cent saturation to 25 per cent by simply raising the temperature to the point of comfort. This is what results when outdoor air is heated to 70 deg. with no provision for supplying additional moisture, except that the outdoor air is not always at the point of saturation and therefore the final result is an atmosphere in which the relative humidity is even less than 25 per cent. Observations made in many buildings heated by hot air, hot water and steam show that there is little difference what system of heating is used, the effect on the relative humidity is practically the same. The relative humidity of nature's air, except in a few localities where peculiar climatic conditions exist, is about 75 per cent, but when artificially heated and thus robbed of over 60 per cent of its natural moisture, becomes drier than the driest climate known.

The evaporative power of air with a relative humidity of 25 per cent is very great. It will seek out and absorb every particle of moisture it can reach. Furniture will dry up and fall apart; books loosen in their bindings; seams open in the woodwork and unsightly cracks appear. Such an atmosphere is unnatural and unfit to breathe and tends to induce a condition of the respiratory tract that sooner or later invites disease. When the mucous membranes of the throat and lungs are subjected to this drying process, the glands which supply the membranes with moisture to keep them in proper physiological condition are irritated and stimulated to do increased work. An increase of work results in an increase of size and functional activity and thus tends to develop an abnormal condition which finally prepares the surface for the reception of the germs of disease. By far the greater proportion of catarrhal troubles in this climate are traceable directly to the lack of sufficient moisture in living rooms to bring the humidity to something near the natural condition of the outside air. Dr. Baxter, in his work on Weather Influences, shows very clearly that dry air in school rooms causes irritability, restlessness, and a condition of nervous tension both in teachers and pupils, the humidity and deportment curves being so uniform as to leave little room for doubt that the relation is other than that of cause and effect. That annoying cough that so often attacks children after coming in from play in the open air is due to the irritation caused by dry air and will continue until the glands of the throat respond to the call for a larger supply of moisture.

On the other hand the evaporation of a tea-kettle of water will be more effective than cough mixtures in bringing rest and quiet to a house disturbed by that irritating, brassy, winter-night cough of children. It is not impossible that the excellent results that have attended the outdoor treatment of pneumonia and kindred diseases are largely due to the natural condition of the atmosphere with respect to moisture thus obtained.

The economic advantage of atmospheric moisture as a coal saver is equally interesting. A moment's thought will recall the fact that we frequently sit out of doors in June with perfect comfort when the temperature is little above 60 degrees. Such a temperature indoors in winter would be decidedly uncomfortable. Have we any good reason for being comfortable at one time and chilly at another? The temperature in both cases is the same, but the outdoor air in June is moist while the indoor air in winter is dry. Dry air makes us cold. Our bodies being warmer than the surrounding air radiate heat into it. Moist air absorbs radiated heat and is warmed by it, but heat goes right through dry air without warming it very much; so we lose more heat in a dry atmosphere than in a moist atmosphere.

Again, evaporation is constantly going on from the surface of our bodies. Evaporation requires heat and the heat in this case is drawn from the body. Evaporation proceeds more rapidly in dry air than in moist air and, so, more heat is taken from the body in the presence of a dry atmosphere than when the air contains a greater percentage of moisture. Prof. Johnson says: "Were it not for the moisture in the air it would be too cold to live in. Humidity in the air is Nature's great bed-blanket for all her children without which they would all perish. So, likewise, moisture in living rooms acts as clothing and helps to keep us warm."

Living rooms heated to 65 deg. and supplied with 50 per cent of moisture are more comfortable and more healthful than when heated to 70 deg. or 72 deg. with 25 per cent of humidity. The fuel required to raise the temperature from 65 deg. to 70 deg. might, therefore, better be saved.

It has been claimed that there will be little or no saving of fuel by heating to 65 deg., and supplying moisture because the heat used to evaporate water to supply the necessary moisture might otherwise be utilized to raise the temperature. It is true that heat is required to evaporate water, but the heat so used is not lost. It is stored up in the vapor, rendered "latent," and passes into the room with the vapor; and when the vapor is condensed on the cool surfaces the heat is set free or "liberated," which means that it again possesses the same power to raise the temperature as when it came direct from the furnace or the radiator. There can, therefore, be no loss of heat by using it to evaporate water to moisten the air in living rooms.

Unfortunately even in modern systems of heating, little attention is given to the need for moisture and the householder is left to supply the deficiency as best he may. Most hot air furnaces are equipped with water pans which if located where there is sufficient heat to evaporate a considerable quantity of water, say 6 to 8 quarts for a ten-room house in 24 hours, a fairly moist atmosphere will be obtained. In hot water and steam heating a water tank attached to the radiators will afford considerable relief but will hardly take the place of a well-filled tea-kettle on a kitchen range.

ENGINEERING NOTES.

Prof. A. G. Ashcroft has devised an interesting lecture table testing machine. The machine, which is used at the Central Technical College, is intended to exhibit to large classes the elastic and plastic properties of the materials used for constructive purposes, iron and steel being the most important. Small specimens, 10 inches long and ⅛ of an inch square in section, are used. The elastic properties of the specimen are determined by gradually applying loads, which must not exceed the elastic limit, and observing the corresponding extension multiplied about 250 times by an extensometer. The plastic properties are shown by drawing a stress-strain diagram on smoked glass and projecting this, while being drawn, on a screen by a lantern.

Since the conclusion of the National Physical Laboratory's research on the resistance of surfaces in a uniform current of air, it has been suggested that valuable information would be obtained if similar experiments could be made at velocities approaching 1,000 feet per second. Further, as the existing experimental air-channel is not suitable for many of the tests on anemometers and other instruments used in a horizontal current, it is proposed to reconstruct the apparatus in such a way that the air will make a complete circuit. In this arrangement there would be three experimental chambers, one for horizontal currents and two for vertical currents, of high velocity and moderate velocity respectively. It is anticipated that the difficulties in setting up a current of the velocity required will be considerable and it is therefore proposed to make a small model of the arrangement initially, in order to form an idea of the power and number of the fans required.

The most recent statistics relative to the coal production in France show two economic facts which are striking. The first of these is that in the last six years, contrary to the preceding order, the consumption of coal in the country remains nearly stationary about 48.5 million (long) tons. In 1900 it was 48,800,000 tons, and comes to 48,200,000 in 1903 and 48,669,000 in 1905. The curve which up to that time rose regularly and about continuously from 18 or 19 millions in 1884 according to the usual manner of such curves relating to mineral substances and prime materials, becomes suddenly horizontal, and that of the production follows it, being parallel (34 to 25 million tons). This result, obtained from very trustworthy statistics, seems very paradoxical when we consider the economic development in the entire world and to a less degree in France. One of the causes seems to lie in the great and modern development of hydraulic power in the southeast and the east portions of the country. The practical problem which was advanced by economists for the relatively close epoch when coal would fail, commences to receive a practical solution, and it would be interesting to see whether the same is true all over the globe. Another cause is the better use of combustible, seeing that efforts are made to economize such materials owing to their increasing price, by a more rational method such as steam or hot air heating, use of waste gases of blast furnaces, etc., without speaking of accessory combustibles such as gasoline. The second economic phenomenon which has an influence upon the first, is the rise in the price of coal, seen in the curve not by a continuous movement, for these are periodic fluctuations, but by the elevation of the minimum points of the curve. Thus can be seen a result of social measures which finally, when the equilibrium is established, always strike the consumers.

SCIENCE NOTES.

Dr. J. T. Bottomley, F.R.S., and Mr. F. A. King conducted experiments before the Royal Society with vacuum gold leaf electroscopes, on the mechanical temperature effects in rarefied gases. The apparatus exhibited consisted of a "radium clock" and various types of vacuum electroscopes. The vacuum electroscopes were set up to show the effects of radiations from sources of heat and light upon gold leaves hanging within highly exhausted inclosures. The gold leaves of the vacuum electroscope diverged when illumination of any kind fell upon them, and stood permanently apart when placed in bright daylight. By suitably manipulating such sources as a spirit flame, candle, or Nernst lamp, near the electroscope, forces which vary in direction and magnitude from point to point within the inclosure were generated, and cause the leaves to be twisted into curious shapes. The gold leaves will remain in this contorted condition for a considerable time after the exciting cause has been removed. Gold leaves hung in unexhausted inclosures are also exhibited for the sake of comparison.

During the course of the determinations of stellar velocities in the line of sight at the Mills Observatory in Chili, various changes in the appearances of the lines selected for measurement have been noted. Mr. S. Albrecht describes how from a discussion of numerous plates it has been concluded that many of these variations may be ascribed to the multiple character of the spectrum lines employed in the reduction. A very severe test for the validity of this view is the comparison of the types of stellar spectra, and it is shown with a considerable degree of certainty that there is a direct sequential variation of these special lines as we pass from stars of one spectral type to another. Now we know that many of the lines photographed in stellar spectra are multiple, although with the dispersion at present available the components may be indistinguishable. In passing from one type of star to another, one of these components may be strengthened or weakened relatively to the others, and thus alter the position of the center of the blended line, which is measured by its maximum intensity. Doubtless in many cases such variations have been measured as velocity changes, whereas they may not be so. Examples are given of definite cases of this type of blended line in the region covered by the Mills photographs, λ 4258 to λ 4468, with the corresponding changes of intensity in Arcturus, the solar spectrum, and the spectra of sunspots, and also short notes on the appearance of the lines in other stellar spectra.

M. Adrien Karl makes a study of some interesting luminous phenomena in a paper read before the Académie des Sciences. Certain substances have the property of emitting light when they are broken or crushed, and this property has been designated as "tribo-luminescence." It is not exactly known what are the causes of the phenomenon and what relation it has to phosphorescence. The author succeeded in preparing a class of bodies which possess this property in the highest degree, but whose phosphorescence due to exposure to the light is almost zero. These substances show such a high effect when crushed, that if they are crushed by a glass rod or metal, or rubbed with emery, we observe an emission of light which is visible even in daylight. In the dark the phenomenon is very strong and allows of distinguishing printed letters of a newspaper. The presence of air is not needed, for the same phenomenon is observed in water, carbon disulphide, ether, etc., and in tubes having had a vacuum made after filling with hydrogen or nitrogen. The substances which are most luminescent were prepared by the author by heating to a high temperature solid mixtures of sulphide of zinc and of salt which were quite varied, such as nitrate of manganese, silicic and stannic acids, zirconia, and silicates or zirconates of manganese. As an example the preparation of two of these bodies which show the phenomenon most clearly will be described. We mix by grinding in a mortar, nitrate of manganese 1 part and zinc sulphide 5 parts. The mixture is then heated to a temperature of about 1,200 deg. C. for 20 or 30 minutes. When the crucible is cooled the mass is thrown into water, then it is crushed, and dried after washing. The temperature of the heat is followed by a Le Chatelier pyrometer, and the influence of the proportions of the mixture is well observed. Another mixture consists of silicon or tin oxide 1 part and zinc sulphide 10 parts. Still better results are obtained by using silicate or stannate of manganese 0.75 part and zinc sulphide 5 parts. A too high heat has the effect of losing a great part of the zinc sulphide by sublimation. Oxide of zinc was substituted for the sulphide, but the substances are very slightly luminescent in this case. These substances in general have a crystalline appearance and their color varies from pinkish yellow to greenish yellow. Tests were made to see whether these bodies could be considered as well-defined chemical compounds. The author made a great number of analyses, but the results were too variable to give any chemical formulæ. It does not appear certain that the property of tribo-luminescence is due to the presence of definite compounds, and may be due to the presence of impurities which are difficult to separate, on account of

the method of formation. The author is making tests upon the radiations emitted from these bodies with the hope of solving the problem.

TRADE NOTES AND FORMULÆ.

To Dye Bast Mat-Work Brown.—Keep the bast cloth over night in a solution of tin salt; next morning rinse it out in a pan of water. Heat a kettle of water to the boiling point and add 2,000 parts of fustic, 1,000 parts of fine madder, 100 parts of cudbear. Allow it to boil for a while. Then boil the bast fabric in it. Then add 1,500 parts of catechu and 1,500 parts of green vitriol with some nitrate of mercury. Boil for two hours, rinse, and pass through warm water.

To Make Aniline Bronze Iridescent.—Objects that have been coated with a solution of 3 parts by weight of fuchsine and 2 parts of shellac in 30 parts of strong alcohol, develop, when the coating is dry, a bronze color. If the object is placed in a low box with glass sides, in the bottom of which a saucer containing fresh chloride of lime is placed, in the course of a few hours the bronze effect of the article will have changed and it will have assumed an iridescent (rainbow color) appearance.

Elastic Vessels for Fluids (Saucers, Dishes, Jugs, Pots, Etc.)—A suitable woven wire form, to which the desired shape has been imparted, is immersed in a thick-fluid mixture of 60 parts by weight of gutta percha, 25 parts of colophony, 8 parts collodion, 5 parts chloroform, and 2 parts of alcohol; thickened with clay, magnesia, etc., colored with lampblack or brownstone. The mixture will be retained in the meshes of the woven wire, forming when cool a continuous coating. The vessel can now be pressed in a suitable form and smoothed with a warm iron.

Pastes for Strops.—For the sharpening side: *a*. Tin putty, 2 parts; crocus, 2 parts; iron scale, 1 part; levigated Turkey oil stone (novaculite), 7 parts, all finely pulverized, mixed with 3 parts of beef suet to form a stiff paste. *b*. 1½ parts crocus, 1½ parts of pumicestone, 4½ parts of graphite, 2 parts bloodstone, 1 part iron filings, all reduced to the finest powder, washed, dried, and rubbed down with 2 parts of vegetable wax; 2 parts soap, 2 parts hog's fat, and 2 parts of olive oil, all warmed and mixed. For the polishing side: *a*. Tin putty rubbed through the finest sieve with water and mixed with axle grease. *b*. Levigated graphite well rubbed down with olive oil.

To clean bed feathers by means of an apparatus that will remove grease and dust, separate and loosen them, etc., the apparatus that will be found most practical should be constructed as follows: The lower portion consists of a furnace with a small boiler in which the steam used in cleaning the feathers can be generated. Various chemicals can be added to the water used. A complete separation of balled masses of feathers can be effected by means of a shaft equipped with arms or beaters and revolving in a closed box or in a revolving drum, the interior or shaft of which is set with projecting studs. For drying purposes a current of air heated in the furnace is led through pipes into the box. The dust can readily be expelled from the perfectly dry feathers by beating.

Production of Celluloid.—To a mixture of 100 parts ether, of a volumetric gravity of 0.728, and 25 parts of camphor, stir in and dissolve 50 parts of collodion cotton, kneading the mass between two vertically disposed rolls until it assumes a plastic form. (If colored celluloid is desired, the coloring matter is added to the ether or to the raw material during the kneading process.) The rolled-out sheets are exposed to the air until they harden. For billiard balls, etc., thin sheets are rolled together, and after partial evaporation of the ether are coarsely pulverized by means of a circular rasp. Celluloid dried on a warming table at 223 deg. F. is pressed in heated iron molds, the pressure being increased by means of screws and hardened by gradual heating (temperature raised in 1¼ to 1¾ hours to 248 to 252 deg. F.), after which the celluloid is allowed to cool.

THE
Scientific American Supplement.
PUBLISHED WEEKLY.

Terms of Subscription, $5 a year.

Sent by mail, postage prepaid, to subscribers in any part of the United States or Canada. Six dollars a year, sent, prepaid, to any foreign country.

All the back numbers of THE SUPPLEMENT, from the commencement, January 1, 1876, can be had. Price, 10 cents each.

All the back volumes of THE SUPPLEMENT can likewise be supplied. Two volumes are issued yearly. Price of each volume, $2.50 stitched in paper, or $3.50 bound in stiff covers.

COMBINED RATES.—One copy of SCIENTIFIC AMERICAN and one copy of SCIENTIFIC AMERICAN SUPPLEMENT, one year, postpaid, $7.00.

A liberal discount to booksellers, news agents, and canvassers.

MUNN & CO., Publishers,
361 Broadway, New York, N. Y.

TABLE OF CONTENTS.